<u>FINAL REPORT</u>

FISH HABITAT AND SALMONID ABUNDANCE WITHIN MANAGED AND UNROADED LANDSCAPES ON THE CLEARWATER NATIONAL FOREST, IDAHO

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INTRODUCTION

Aquatic ecosystems in the eastern Columbia Basin have been greatly affected by natural and anthropogenic disturbances over the last 150 years. Within this region, catastrophic wildfires, road construction, logging, mining, livestock grazing and other activities have at various times and locations had deleterious effects on streams and native aquatic biota. Some of the damaged aquatic systems have recovered since disturbance, others appear to have stabilized at much reduced levels of productivity and many continue to experience chronic degradation. Sensitive aquatic species dependent upon these systems are in decline and several have received federal designation as threatened or endangered species.

Recent concern over declining ecosystem health in the eastern Columbia Basin has prompted the USDA Forest Service and other federal agencies to begin a comprehensive analysis of current environmental conditions and trends across the region. When completed, the analysis will include a thorough examination of available information on stream conditions and sensitive aquatic species. The following report provides a summary of detailed fish habitat and abundance data recently collected on streams within the Clearwater National Forest (CNF) in north-central Idaho. These data, and information others provide on streams elsewhere within the region, will help provide a technical basis for the ecosystem analysis to be performed.

CLEARWATER DATABASES

Over the last eight years, we have collected fish habitat and salmonid abundance data on about 250 streams in north-central Idaho. The- streams surveyed were affected by a diversity of natural and anthropogenic disturbances and flowed from designated wilderness, unroaded areas, or managed watersheds subjected to varying levels of disturbance. Data collected along the streams, particularly streams we examined using a transect method (Espinosa 1988) within the CNF, provide a useful basis for assessing disturbance-related differences among streams within a portion of the eastern Columbia Basin.

Under contract to the Eastside Ecosystem Management Project, we have developed two databases on conditions along CNF streams we have surveyed using Espinosa's (1988) transect methods. Information within the databases is based on field work and analyses we have performed under contract to the CNF (CBS 1989, CBS 1990, CBS 1991, CBS 1992, CBS 1993). One database (HABITAT) contains detailed fish habitat infon-nation on 1320 distinct reaches of stream that were surveyed from 1989 through 1993 (see Appendix A). Those reaches had a combined length of 1090 km and were scattered across much of the 4620 km^2 CNF. The other database (FISH) includes species composition and abundance data for salmonids at 668 fish stations sampled at representative locations along the same reaches (see Appendix B). Both databases were created using Microsoft Excel and are in a spreadsheet format (".XLS") that is easily converted to formats used by other popular software.

The two Clearwater databases have been linked to a set of 1:100,000-scale maps by delineating each individual stream reach and fish station on metric USGS quads of that scale (see Appendix C). Spatial analyses of the databases will be possible after reach and fish station locations delineated on the USGS quads have been digitized by the USDA Forest Service and incorporated into a geographic information system (GIS). Incorporation of the database into a GIS was outside, the scope of our contract.

CONDITIONS IN MANAGED VERSUS UNROADED AREAS

I stratified fish habitat and salmonid abundance data for the stream reaches we have surveyed on the CNF by major channel type (Rosgen 1985; C, B, A., and AA) and landscape treatment (managed and unroaded’) in order to assess possible cumulative impacts on streams in this portion of the eastern Columbia Basin. My analysis grouped E and G-type channels surveyed in 1993 with C and B-type reaches, respectively, because that is how those two types of channels were classified prior to 1993. General characteristics of the four major channel types used to stratify stream-related data are summarized below for readers unfamiliar with the classification system Rosgen outlined in 1985:

Channel type	Stream gradient	Channel confinement	Sinuosity
C	low (<1.5%)	slight	high
B	moderate (1.5-4%)	moderate	moderate
A	high (410%)	strong	low
AA	very high (> 10%)	strong	low

Reaches we surveyed within designated wilderness[2] were pooled with those classified as unroaded, because too few wilderness reaches have been examined to provide a clear picture of stream conditions within the Forest’s wilderness lands. Stream conditions within those lands will become more clearly understood as additional data are collected over the next several years.

Before discussing current differences between streams in unroaded and managed landscapes on the Forest, I should note that differences likely existed between these areas even before roads were constructed in the managed areas. This is due in part to a pattern of development which has not been evenly distributed across all elevation ranges, geomorphic features or histories of natural disturbance. With regard to historic

[1] Unroaded streams were those which drained watersheds that either lacked roads or had such limited road networks that their character was essentially unroaded. Managed streams were those draining watersheds with roaded character, ranging from systems with modest road networks to drainages with very high road densities.

[2] The Clearwater National Forest includes 652 km’ of the Selway-Bitterroot Wilderness Area.

disturbances, a high proportion of the remaining unroaded watersheds within the CNF are still recovering from massive forest fires which occurred during the last SO-150 years. For this reason, many or most of the current roadless area streams included in our database exhibit aquatic habitat conditions that are below the streams' potentials. Fish habitat in the unroaded streams therefore does not necessarily represent an optimal condition against which to measure the degree to which other suearns may have been affected by natural or anthropogenic disturbances. On average, streams in managed areas may well have been in better condition (relative to potential) before their watersheds were first roaded than many of the remaining unroaded streams are today.

FISH HABITAT IN MANAGED VERSUS UNROADED STREAMS

I compared the abundance of large woody debris and pools, bank stability, and substrate conditions in managed versus unroaded streams of each major channel type surveyed within the CNF. Comparisons were based on the mean condition of surveyed reaches of each channel and treatment type as well as on the observed range of variability among managed versus unroaded reaches for each habitat parameter examined[3].

A supplemental analysis was performed on habitat data we collected on low gradient, C-type channels because they tend to be the most sensitive to landscape disturbance. For those reaches, habitat exceedance curves (Huntington 1994) were developed for several key parameters[4]. The curves are essentially cumulative frequency distributions that depict both the frequency and the range of mean conditions found in managed versus unroaded stream reaches. The exceedance curves represent a relatively unconventional analytical

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[3] Habitat transects were examined at constant 30 m or occasionally at constant 60 m intervals along each reach of stream surveyed on the CNF. Means, ranges of variability, and standard errors reported here for specific habitat parameters were based on analyses of average reach conditions, with each reach given equal weight regardless of reach length Average conditions for individual stream reaches were determined through earlier analyses of the habitat characteristics at each habitat transect within each reach.

[4] The frequency distributions for reach-based average values of selected habitat parameters were calculated using the PERCENTILE function of Microsoft Excel (Microsoft Corporation 1992).

technique that seems quite helpful in addressing landscape-level questions about stream and riparian conditions.

In addition to the potential for differences in stream conditions between managed and unroaded landscapes, it is important to note that the cumulative effects of varied land-use activities have not been evenly distributed across the stream channel types present on the CNF. This is important because certain aquatic animals prefer specific types of channels. For example, stocks of spring chinook salmon (*Oncorhynchus tschawytscha*) threatened with extinction tend to prefer slow-flowing habitat prevalent in C-type channels which are sensitive to disturbance. Of the stream reaches we have surveyed on the CNF, 39 percent of AA channels, 46 percent of A channels, 64 percent of B channels and 84 percent of C channels have been classified as managed. Generally, roadless streams were dominated by moderately steep to very steep channels while most of the sensitive, low gradient channels were within managed landscapes.

Large Woody Debris.

Two types of large woody debris have been measured along the reaches we have surveyed within the CNF. Acting debris, stable woody material at least 10 cm in diameter that has an independent and direct instream effect upon fish habitat, has been counted and expressed as pieces of debris per 100 m of stream. Potential debris, the number of standing trees or snags along the stream which are at least 30.5 cm dbh and capable of falling into the stream to become acting debris, has been measured with slope-compensating angle gauges and expressed as pieces per 100 m.

Acting Debris. Differences in acting debris levels among streams in unroaded and managed areas of the CNF probably reflect interactions between cumulative, uneven anthropogenic impacts and a mosaic of natural, ongoing fire recovery processes. On average, we found acting debris to be slightly more abundant in unroaded than in managed C-type reaches (mean = 13.6 v. 11.5/100 m), but less abundant in unroaded than in managed B-type reaches (mean = 10.1 v. 10.9/100 m), A-type (14.5 v. 19.1/100

m) and AA-type (20.0 v. 26.9000 m) reaches (Table 1; Figure 1). Variability in acting debris levels was greatest in A and AA-type channels, with reaches in managed landscapes exhibiting a greater range of debris conditions than reaches in unroaded areas. The ranges of acting debris levels found in C and B-type reaches were similar in managed and unroaded landscapes. However, habitat exceedance curves for acting debris in the sensitive C-type channels show that relatively low and high debris levels were more common in unroaded than in managed reaches (Figure 2).

Potential Debris. Levels of potential debris along reaches in unroaded and managed portions of the forest followed a pattern similar to that exhibited by acting debris (Table 2; Figure 3). Among moderately steep to very steep stream reaches, potential debris was generally more abundant in managed than in unroaded areas. Although potential debris levels tended to be higher along unroaded than managed C-type reaches (mean = 26.9 v. 16.6/100 m), they were lower along unroaded than managed B-type (mean = 23.8 v. 27.0/100 m), A-type (mean = 32.0 v. 37.6/100 m) and AA-type (mean = 35.7 v. 50.7/100 m) reaches. The levels along AA and B-type reaches were more variable in unroaded areas, while those along A and C-type channels showed wider ranges of variation within managed areas. A habitat exceedance analysis for the sensitive C-type channels suggests that the wider range of variation among managed reaches of that type was attributable to a very small number of reaches with atypically high levels of potential debris (Figure 4).

Riparian timber harvest has removed some of the potential debris from areas along many streams within the CNF. I suspect that the greater quantities of potential debris along managed than unroaded B, A and AA-type reaches on the Forest are primarily a reflection of the effects that historic wildfires had on riparian conifers in many currently roadless areas and a higher abundance of timber within currently roaded areas prior to management.

Table 1. Abundance of acting debris (#/100 m), by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed on the Clearwater National Forest from 1989 through 1993.

Channel type	Landscape treatment	Reaches surveyed	Mean	Standard error	Min. value	Max value
C	managed	180	11.5	0.71	0	55
C	unroaded	35	13.6	206	0	44
B	managed	290	10.9	0.52	0	41
B	unroaded	162	10.1	0.87	0	54
A	managed	209	19.1	0.80	0	75
A	unroaded	229	14.5	0.84	0	34
AA	managed	76	26.9	2.00	5	120
AA	unroaded	121	20.0	1.32	0	71

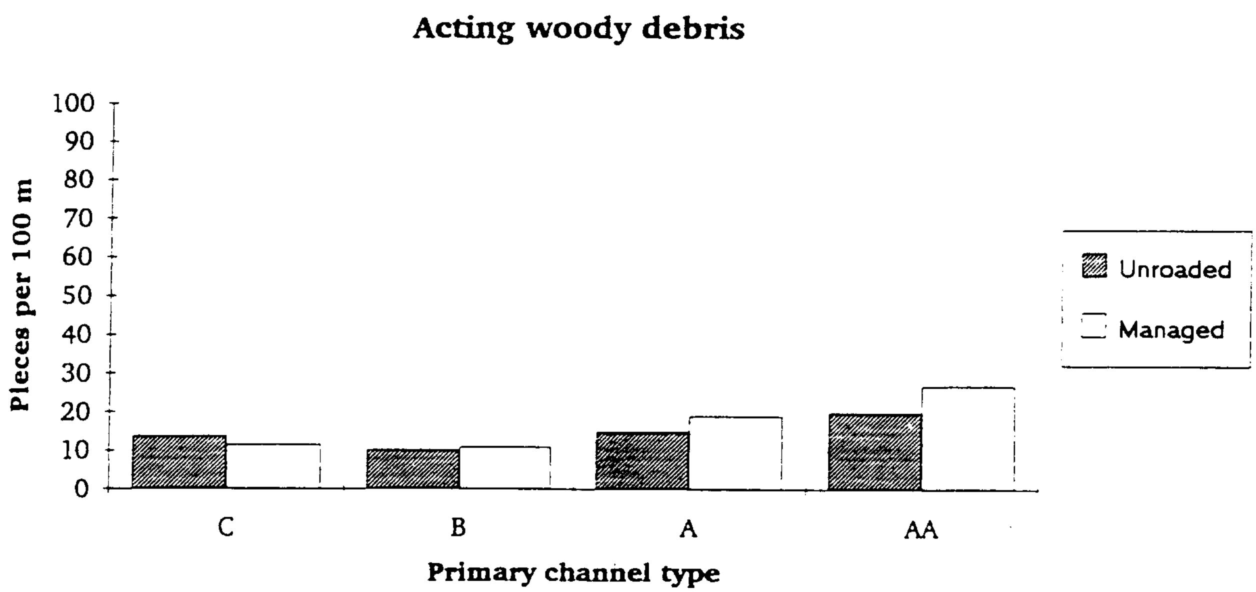

Figure 1. Mean abundance of acting woody debris (pieces per 100 m), by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

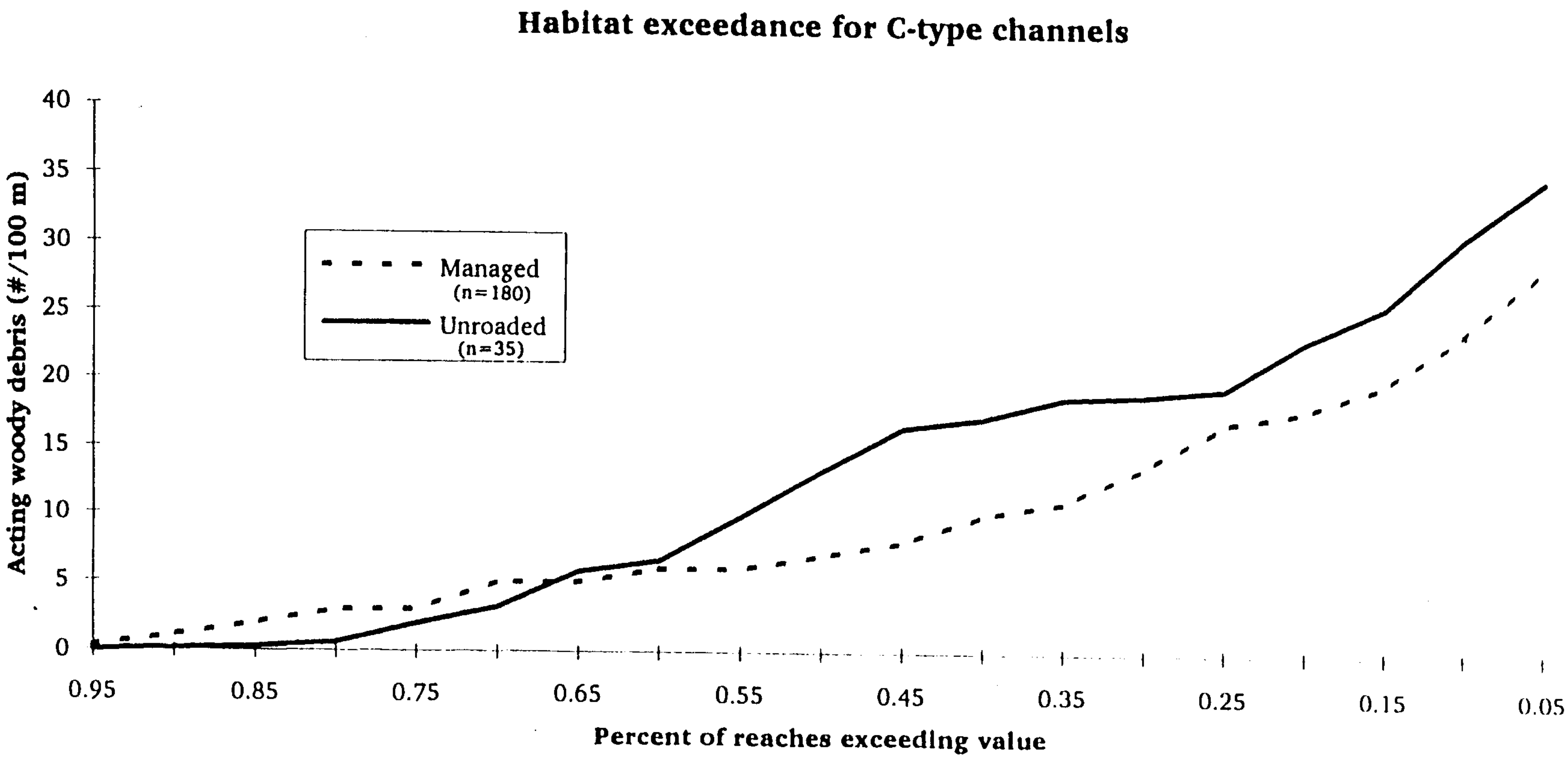

Figure 2. Habitat exceedance curves for acting woody debris (#/100 m) in managed versus unroaded C-type stream reaches, Clearwater National Forest, 1989-1993.

Table 2. Abundance of potential debris (#/100 m), by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed on the Clearwater National Forest from 1989 through 1993.

Channel type	Landscape treatment	Reaches surveyed	Mean	Standard error	Min. value	Max value
C	managed	180	16.6	1.15	0	121
C	unroaded	35	26.9	3.26	1	85
B	managed	290	27.0	1.30	0	104
B	unroaded	162	23.8	1.52	0	131
A	managed	209	37.6	1.73	0	116
A	unroaded	229	32.0	1.59	0	56
AA	managed	76	50.7	2.99	0	136
AA	unroaded	121	35.7	2.65	0	203

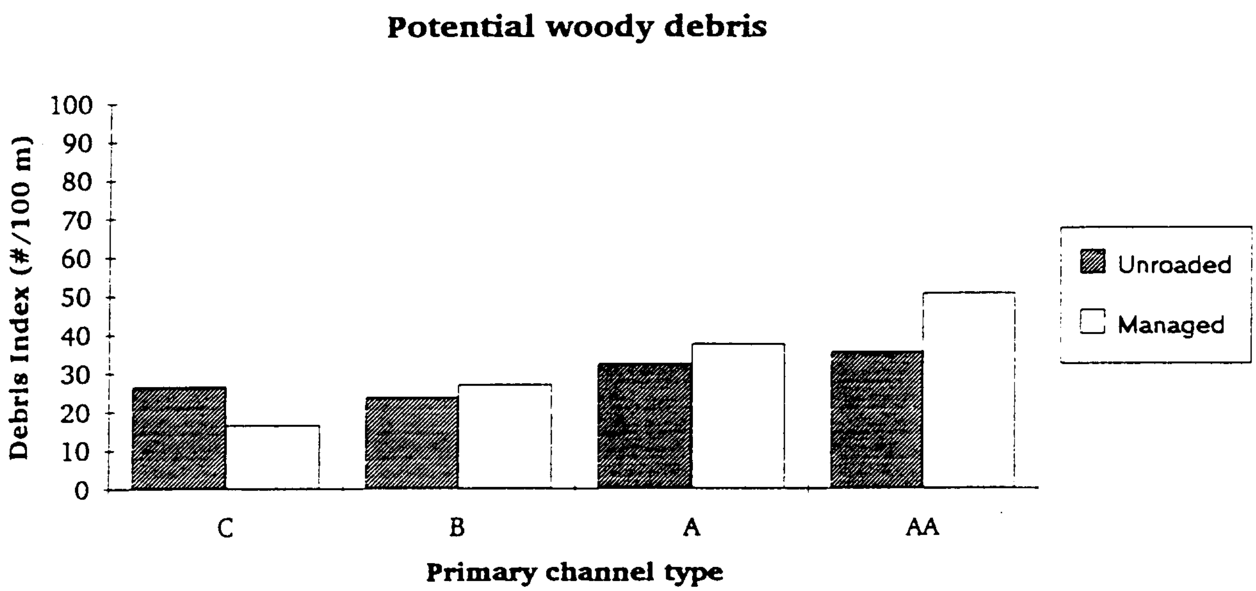

Figure 3. Mean abundance of potential woody debris (pieces per 100 m), by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

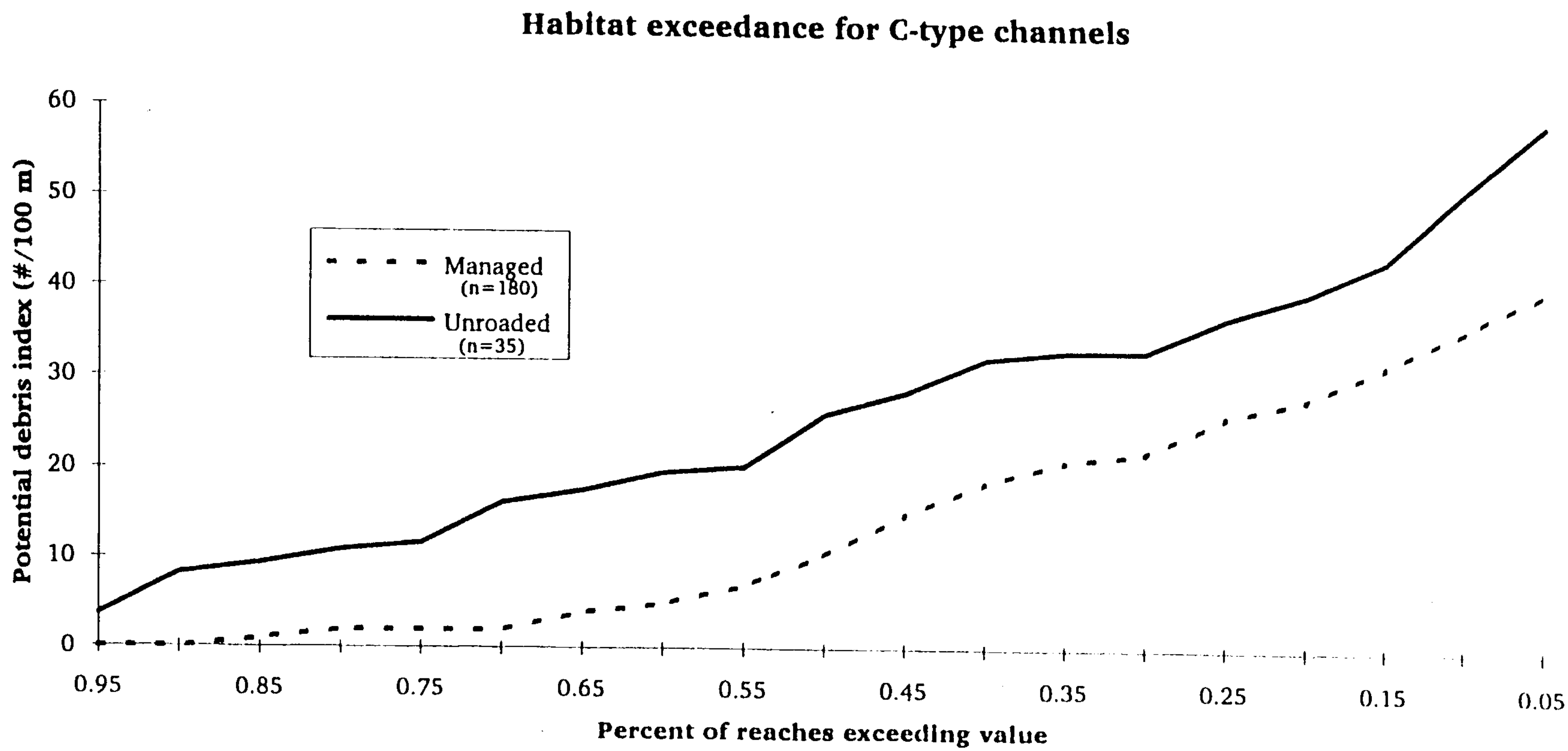

Figure 4. Habitat exceedance curves for potential woody debris (#/100 m) along managed versus unroaded C-type stream reaches, Clearwater National Forest, 1989-1993.

Pool Habitat.

The abundance of pool habitat in streams on the CNF (expressed as percent pool habitat) ranged from extremely low to very high among the reaches of stream we surveyed (Table 3). Pool habitat was most common in C-type channels (Figure 5), within which it was slightly more abundant inmanaged landscapes (mean = 34.8% of stream area) than in unroaded areas (mean = 32.3%). The percent of stream area classified as pool habitat was also slightly greater within managed than in unroaded B-type reaches (mean values 19.2% v. 18.0%), but the reverse was true for A (managed 21.5% v. unroaded 22.9%) and AA-type channels (managed 20.6% v. unroaded 26.7%).

The range of variability in pool abundance provided little discrimination among landscape treatments and was similar for stream reaches in managed and in unroaded areas. A habitat exceedance analysis for C-type channels showed little difference in pool abundance between managed unroaded reaches (Figure 6).

Streambank Stability.

Bank stability along CNF streams has been rated on a scale from 1 (poor: less than 60% stable) to 5 (excellent: 100% stable). With some notable exceptions, bank stability along surveyed streams has been very good to excellent across the Forest (Table 4; Figure 7). On average, bank stability has been somewhat lower along sinuous C-type reaches than along other reach types. It has also been slightly lower in managed versus unroaded C (mean index value = 4.5 v. 4.6) and B-type channels (4.7 v. 4.9).

Differences in bank stability between managed and unroaded C-type stream reaches were pronounced only in the most unstable streams (Figure 8). The least stable reaches surveyed within managed landscapes had notably less stable banks than did the least stable reaches in unroaded areas.

Table 3. Percent pool habitat, by primary channel type and landscape aeatment (managed v. unroaded), for stream reaches surveyed on the Clearwater National Forest from 1989 through 1993.

Channel type	Landscape treatment	Reaches surveyed	Mean	Standard error	Min. value	Max value
C	managed	180	34.8	1.69	0	100
C	utuoaded	35	32.3	4.01	0	88
B	managed	290	19.2	0.94	0	87
B	unroaded	162	18.0	1.10	0	88
A	managed	209	21.5	1.04	0	100
A	unroaded	229	22.9	1.12	0	58
AA	managed	76	20.6	1.57	0	66
AA	unroaded	121	26.7	1.96	0	100

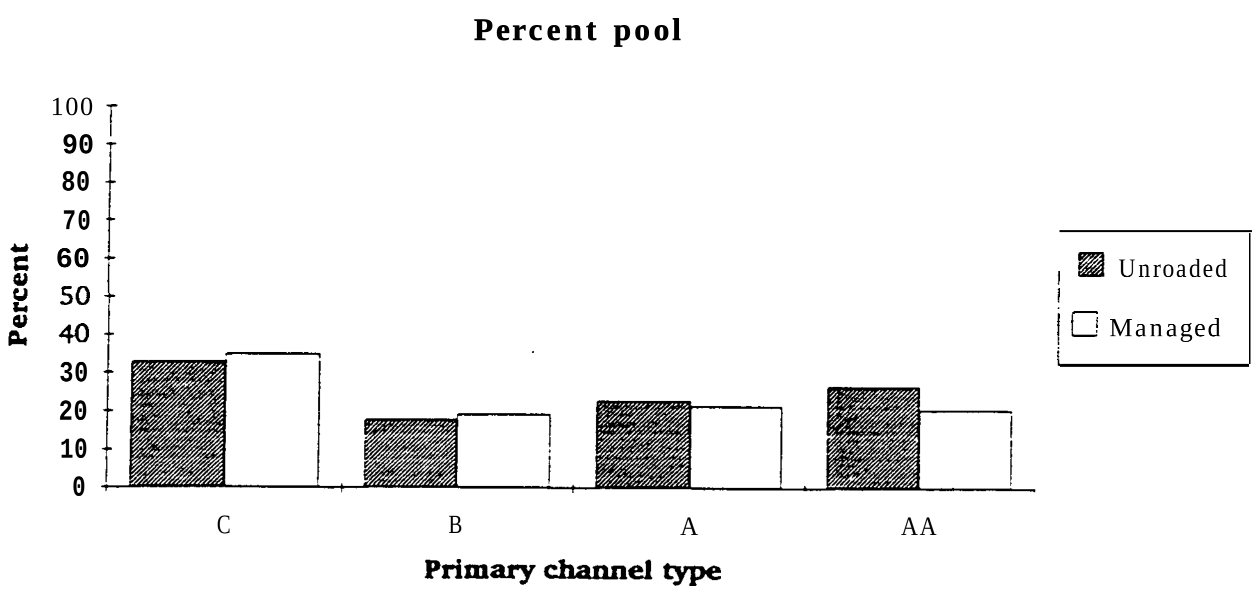

Figure 5. Mean values of percent pool habitat, by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

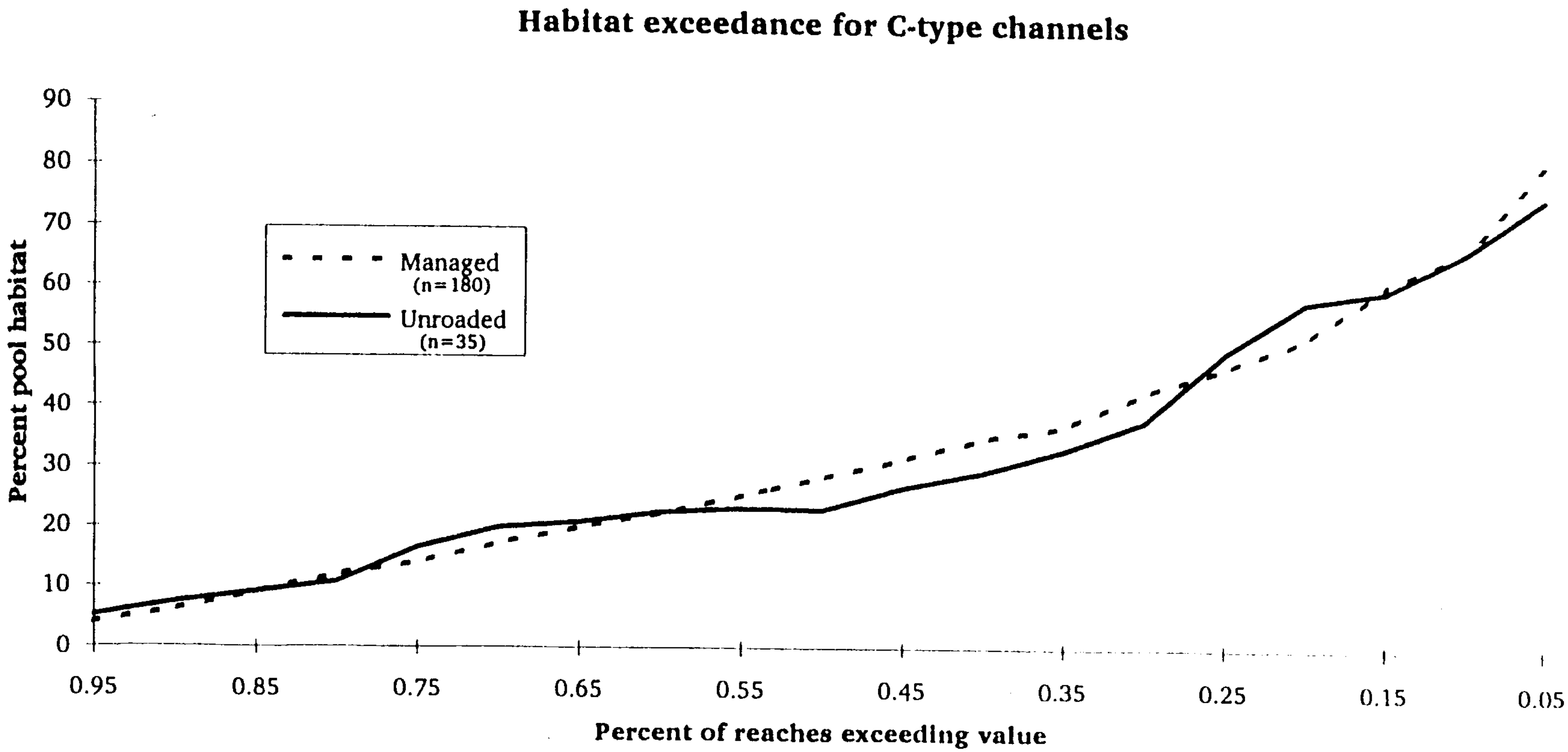

Figure 6. Habitat exceedance curves for percent pool habitat in managed versus unroaded C-type stream reaches, Clearwater National Forest, 1989-1993.

Table 4. Mean bank stability index (see note), by primary channel type and landscape treatment (managed v. unroadedj, for stream reaches surveyed on the Clearwater National Forest from 1989 through 1993.

Channel type	Landscape treatment	Reaches surveyed	Mean	Standard error	Min. value	Max value
C	managed	180	4.5	0.04	2.8	5.0
C	unroaded	35	4.6	0.09	2.9	5.0
B	managed	290	4.7	0.03	1.9	5.0
B	unroaded	162	4.9	0.02	3.6	5.0
A	managed	209	4.9	0.02	2.5	5.0
A	unroaded	229	4.9	0.02	2.8	5.0
AA	managed	76	4.9	0.04	3.5	5.0
AA	unroaded	121	4.9	0.03	2.8	5.0

Note: The stability index ranges from 1 (poor: less than 60% stable banks) to 5 (excellent: 100% stable banks). For additional explanation see Espinosa (1988).

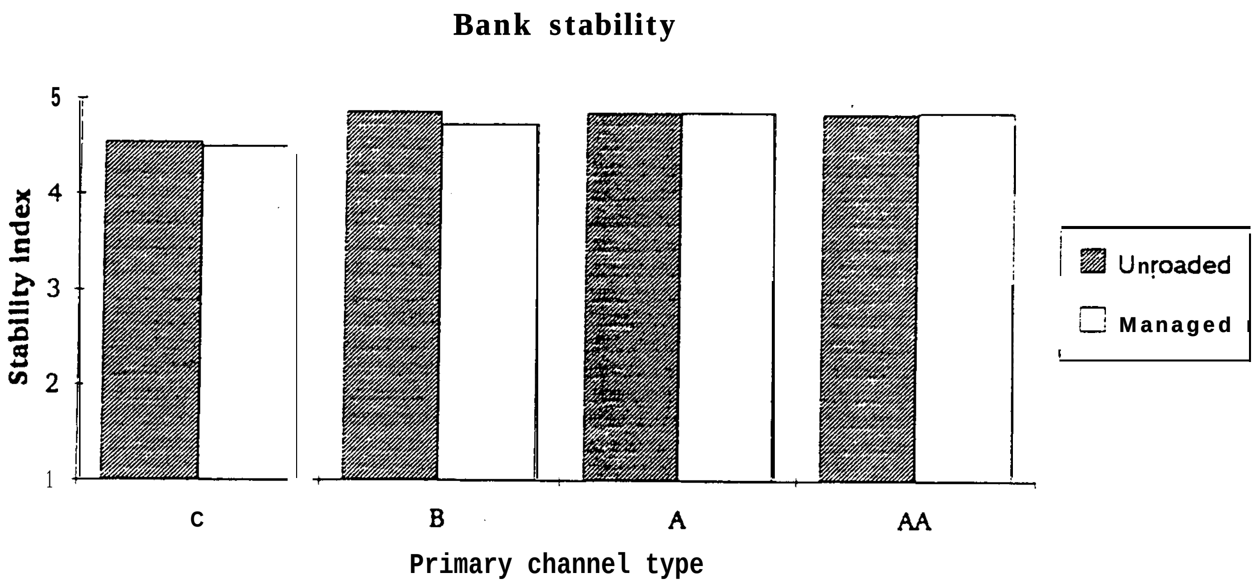

Figure 7. Mean index values for bank stability, by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

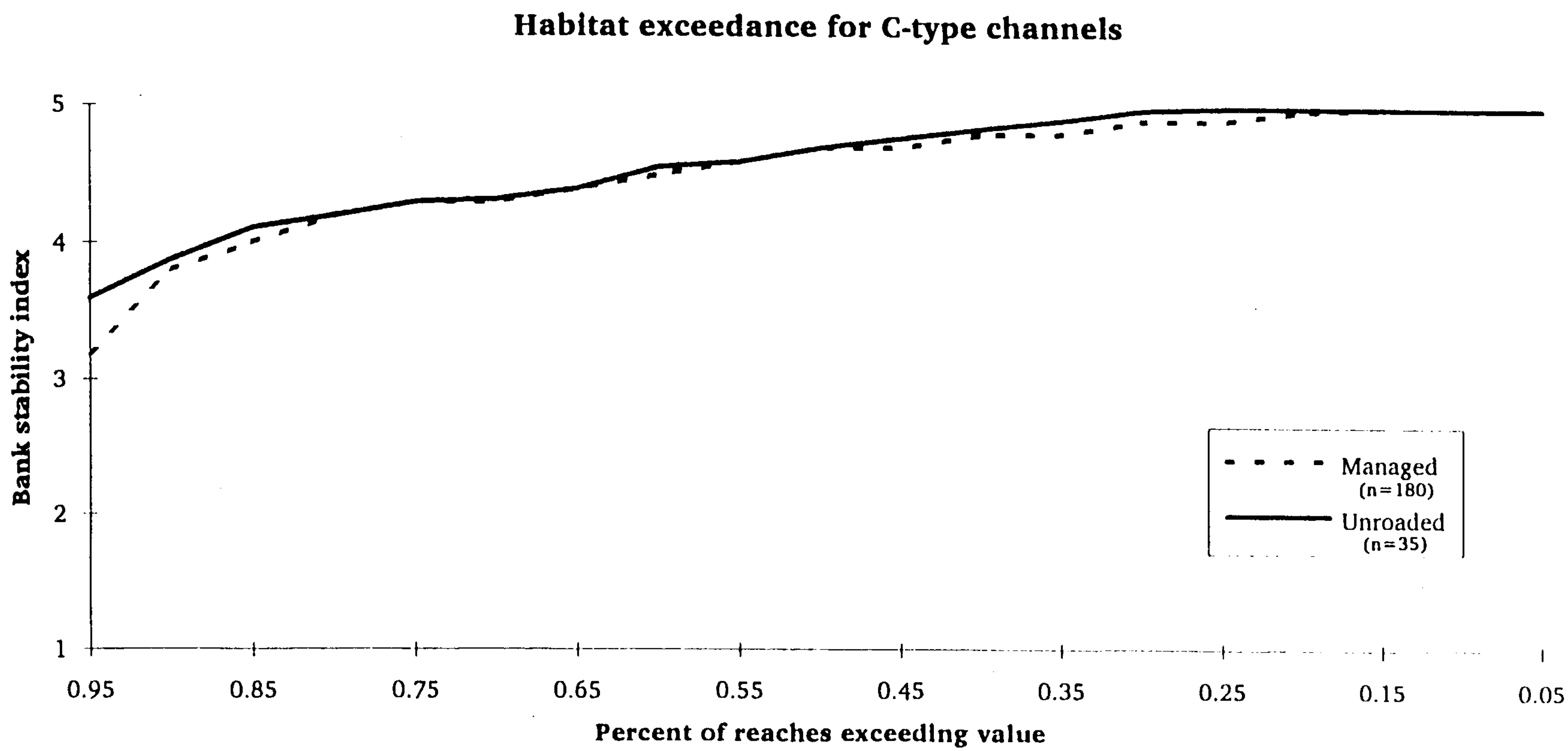

Figure 8. Habitat exceedance curves for the mean bank stability indices of managed versus unroaded C-type stream reaches, Clearwater National Forest, 1989-1993.

Cobble Embeddedness.

Sueambed sedimentation is perhaps the most serious impact of forest management activities on streams and aquatic biota within the CNF. In spite of high sediment levels which persist in some unroaded streams as after-effects of historic fires, we have generally found higher cobble embeddedness in streams within managed landscapes than in those within roadless areas (Table 5; Figure 9). For each major channel type, greater levels of cobble embeddedness have been found in managed than in unroaded areas. The magnitude of differences in cobble embeddedness between managed and unroaded streams generally increased as stream gradients declined, with the greatest differences (mean embeddedness = 72.4% v. 49.1%) observed in C-type reaches.

Comparisons between managed and unroaded streams based on their respective ranges of variation in cobble embeddedness showed only minor difference between the two landscape treatments. For all channel types and ueatments, at least a small number of reaches on the CNF exhibit either extremely high or relatively low cobble embeddedness. However, this lack of differentiation between treatments does not reflect a lack of management-induced sediment impacts on CNF streams. Rather, it points to a potential weakness of assessing management impacts on the basis of ranges of variability without accounting for the frequencies of various conditions within those ranges.

A habitat exceedance analysis for cobble embeddedness in the sensitive C-type reaches we have surveyed provides a clear picture of the types of differences which exist between managed and unroaded streams on the CNF (Figure 10). Although the ranges of embeddedness found in managed and nnroaded C-type channels were relatively similar, low levels of embeddedness were much less common and high levels far more common in’managed than in nnroaded areas.

Table 5. Percent cobble embeddedness, by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed on the Clearwater National Forest from 1989 through 1993.

Channel type	Landscape treatment	Reaches surveyed	Mean	Standard error	Min. value	Max value
C	managed	180	72.4	2.03	6	100
C	unroaded	35	49.1	5.14	4	100
B	managed	290	47.5	1.48	4	100
B	unroaded	162	26.1	1.31	3	95
A	managed	209	42.8	1.39	4	96
A	unroaded	229	30.2	1.26	7	89
AA	managed	76	40.5	2.09	0	94
AA	unroaded	121	34.0	1.85	0	85

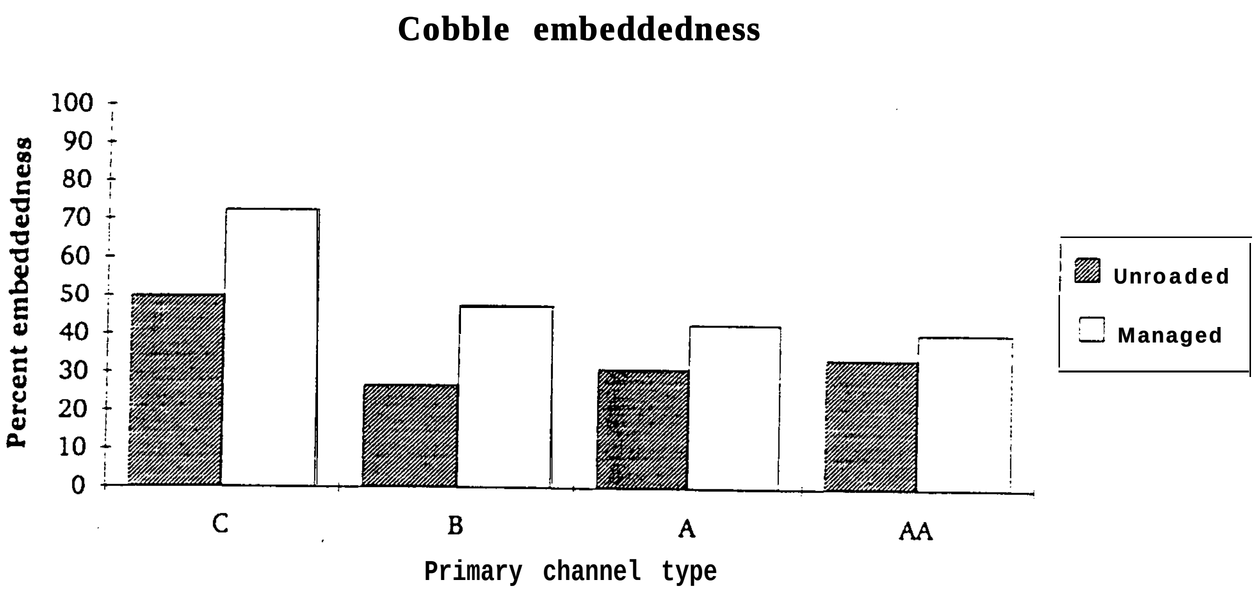

Figure 9. Mean cobble embeddedness, by primary channel type and landscape treatment (managed v. unroaded), for stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

Habitat exceedance for C-type channels

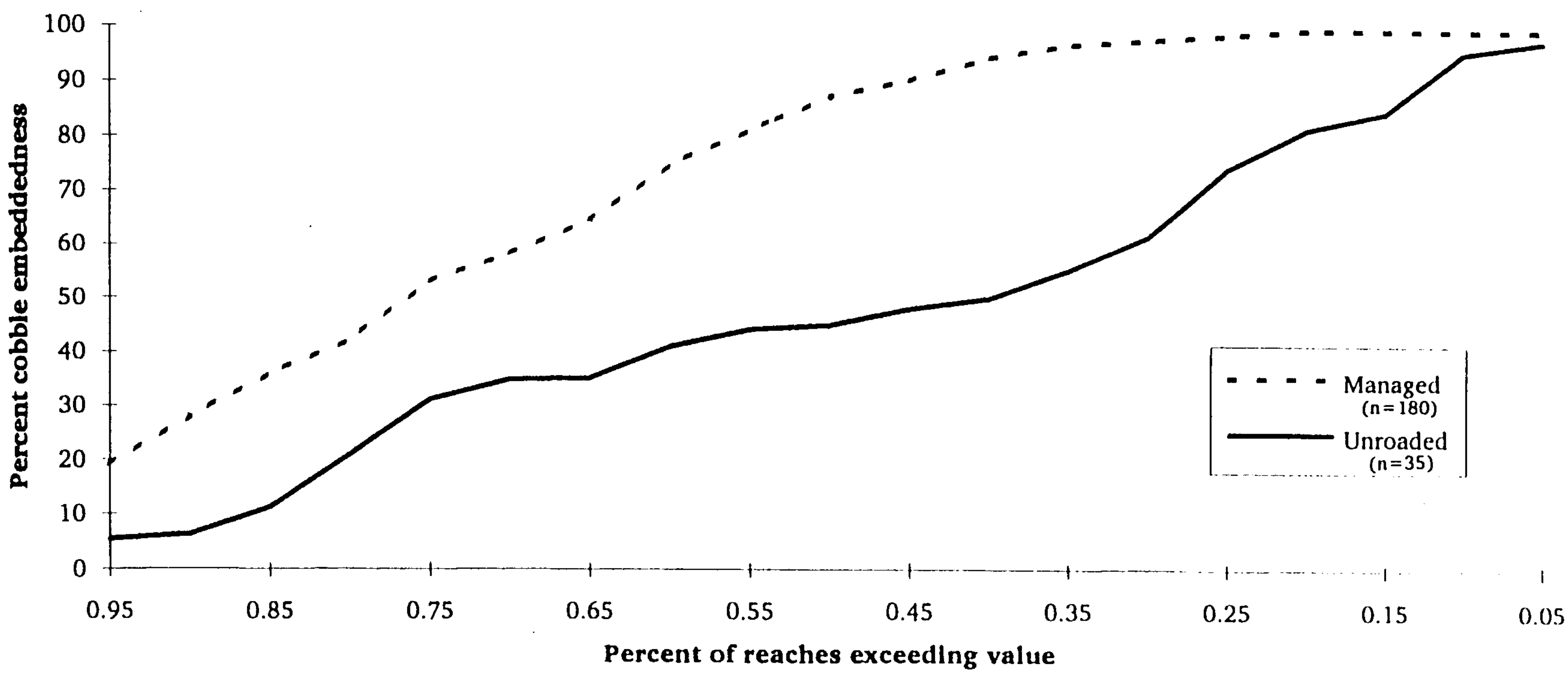

Figure 10. Habitat exceedance curves for the mean cobble embeddedness of managed versus unroaded C-type stream reaches, Clearwater National Forest, 1989-1993.

Substrate Composition.

Streambed subsuates differed among the managed and unroaded reaches of stream we surveyed on the CNF. Average (composite) substrate composition for managed C-type channels (Figure 11) was dominated by fine sediment (57.8%) and cobble (25.0%), while that for unroaded C-type channels was dominated by cobble (36.0%), gravel (27.9%) and fine sediment (24.1%). Fine sediment also accounted for a greater percentage of surface substrate in managed than in unmanaged B, A and AA-type reaches (Figures 12-14). Like cobble embeddedness, difference between managed and unroaded reaches in the proportion of streambed surfaces comprised of fine sediment increased as stream gradients decreased (i.e. from AA through C-type channels).

SALMONID POPULATIONS IN MANAGED VERSUS UNROADED STREAMS

I compared the abundance of salmonid fishes at stations within managed versus unroaded streams for each of the same four major Rosgen channel types considered in the examination of fish habitat conditions on the CNF. Differences between landscape treatments were evaluated in terms of salrnonid assemblages, mean abundances of overyearling trout, and cumulative frequency distributions for the abundance of overyearling uout at the 668 stations we have sampled.

In all cases, my evaluations were based on the mean numerical densities (#/100 m^2) of salmonids we found at representative 30-60 m long stations scattered across the CNF. Estimates of salmonid abundance at those stations were direct snorkel counts except at perhaps 30-40 locations where poor water clarity within managed areas prevented snorkelers from observing fish. Abundance estimates at those locations were developed using standard electrofishing methods.

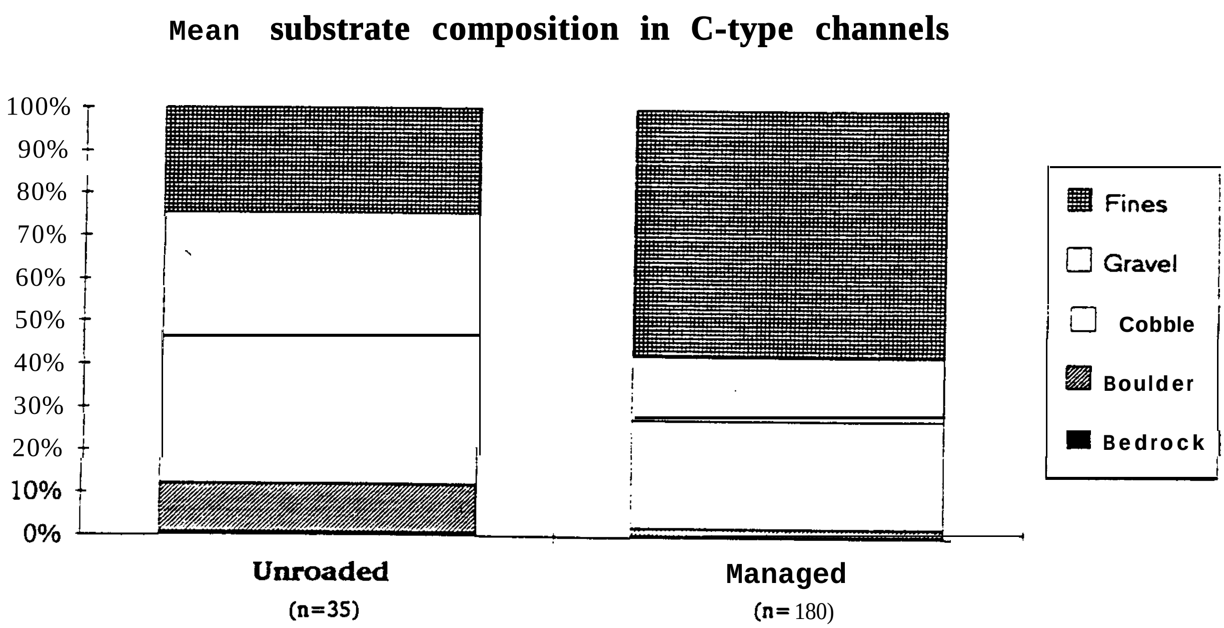

Figure 11. Mean substrate composition, by landscape treatment (managed v. unroaded), for C-type stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

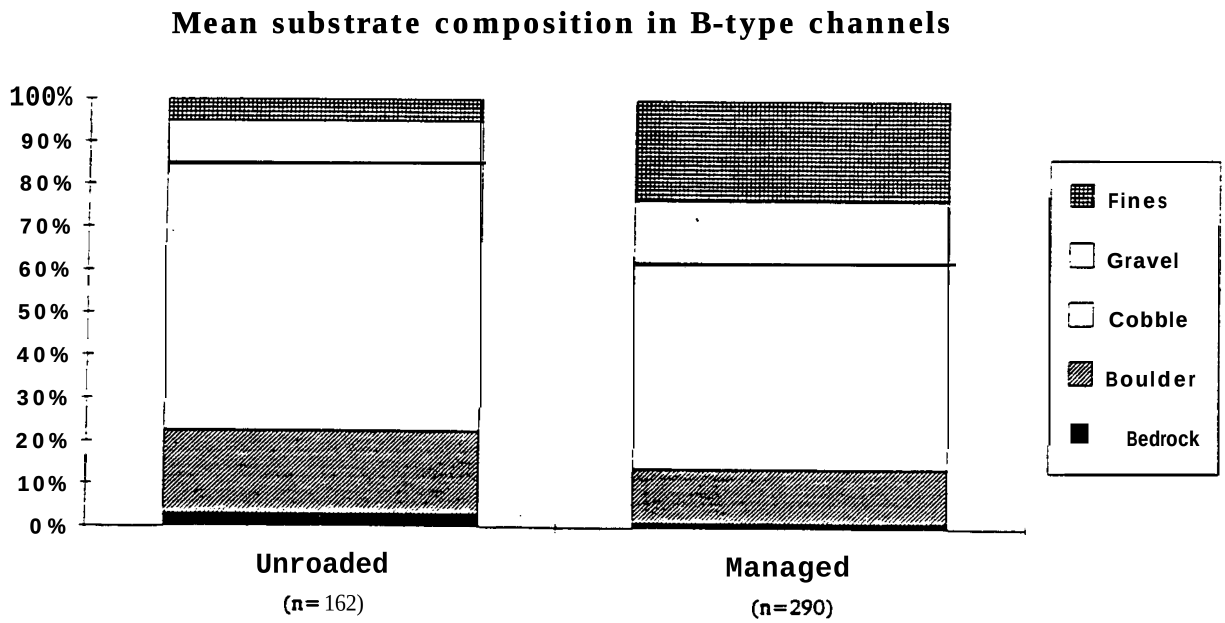

Figure 12. Mean substrate composition, by landscape treatment (managed v. unroaded), for B-type stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

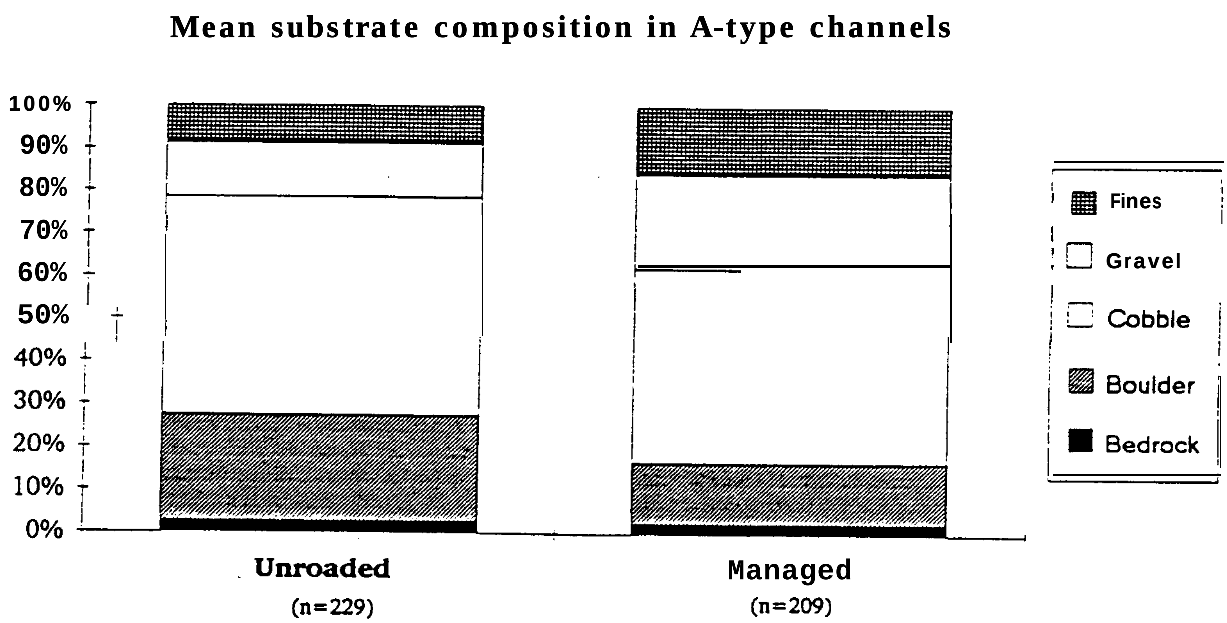

Figure 13. Mean substrate composition, by landscape treatment (managed v. unroaded), for A-type stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

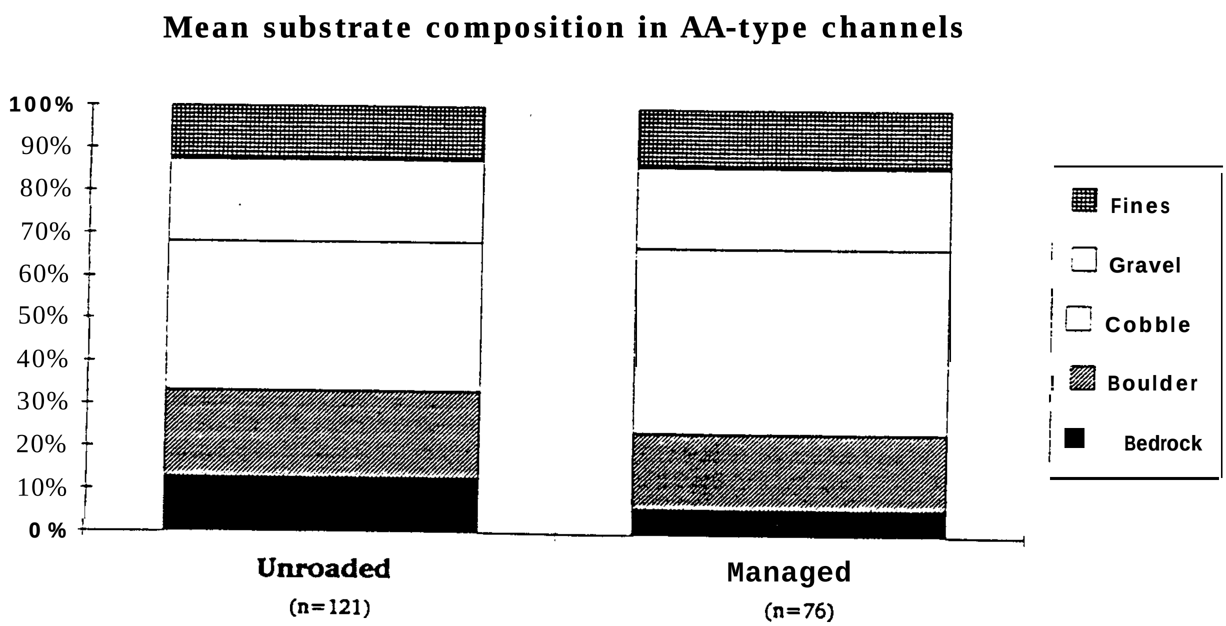

Figure 14. Mean substrate composition, by landscape treatment (managed v. unroaded), for AA-type stream reaches surveyed within the Clearwater National Forest from 1989 through 1993.

Salmonid Assemblages.

Salmonids observed in the streams we surveyed on the CNF included rainbow-steelhead (0. *mykiss*), westslope cutthroat (0. *clarki lewisi*), bull trout (*Salvelinus confluentus*), brook trout (S. *fontinalis*), spring chinook salmon (0. *tschawytscha*) and mountain whitefish (*Prosopium williamsoni*). These species were present within both managed and unroaded landscapes (Table 6). However, the occurrence and relative abundance of each of these species varied by channel type and landscape treatment (Figures E-18). Westslope cutthroat were a numerically dominant member of the salrnonid assemblages in all channel types within unroaded landscapes and in all but C-type channels in managed landscapes'. Rainbow-steelhead were common members of the assemblages in A, B and C-type channels within both unroaded and managed areas. Juvenile chinook salmon were relatively abundant members of the salmonid assemblage only in a few unroaded C and B-type channels, but their presence even in those channels was strongly influenced by hatchery supplementation. Whitefish were observed only at a very small proportion of the fish stations we sampled.

Overyearling bull trout were relatively more abundant members of the salmonid assemblage in unroaded than in managed landscapes, but age 0 fish were observed only at a few stations near key spawning areas within a single managed watershed. The locations at which we have observed age 0 and other juvenile bull trout on the CNF have left me with the strong impression that the species' spawning distribution is strongly skewed toward a very small portion of the landscape. I have speculated that at least in unroaded portions of the CNF, the current spatial distribution of key spawning areas for bull trout may be related to historic patterns of catastrophic wildfire. It has also been suggested that the natural distribution of key spawning areas for the species within the CNF could be related to the presence of certain geologic types or landforms (Dale Wilson, CNF, personal communication).

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[5] We consider "numerically dominant" members of the salmonid assemblage to mean those species whose mean numerical abundance at fish stations is relatively high compared to that of other salmonid species.

Table 6. Mean numerical densities of salmonids (#/100 sq m) and standard errors (x.xx), by primary channel type and landscape treatment, for fish stations sampled on the Clear-water National Forest during Summer, 1989-1993.

Channel type	Landscape treatment	Stations sampled	Age 0 cutthroat	Overyearling cutthroat	Age 0 rainbow trout	Overyearling rainbow trout	Age 0 bull trout	Overyearling bull trout	Age 0 brook trout	Overyearling brook trout	Chinook salmon	Mountain whitefish
C	managed	128	0.15 (0.06)	0.86 (0.30)	0.28 (0.15)	0.64 (0.13)	0.00 (0.00)	0.01 (0.01)	1.82 (0.44)	1.52 (0.24)	0.11 (0.06)	0.01 (0.01)
	unroaded	11	0.91 (0.40)	6.10 (2.19)	0.95 (0.64)	1.48 (0.76)	0.00 (0.00)	0.19 (0.11)	1.63 (1.63)	0.49 (0.49)	2.80 (2.66)	0.04 (0.04)
B	managed	136	1.38 (0.45)	2.65 (0.41)	2.29 (0.58)	1.60 (0.23)	0.00 (0.00)	0.08 (0.05)	1.72 (0.52)	1.42 (0.37)	0.33 (0.16)	0.03 (0.02)
	unroaded	72	0.40 (0.12)	3.51 (0.36)	1.90 (0.46)	2.37 (0.49)	0.02 (0.02)	0.14 (0.05)	0.05 (0.05)	0.15 (0.10)	3.52 (2.68)	0.03 (0.02)
A	managed	116	2.66 (0.48)	6.41 (0.73)	1.77 (0.57)	1.41 (0.27)	0.18 (0.12)	0.11 (0.05)	0.49 (0.20)	0.64 (0.19)	0.02 (0.02)	0.00 (0.00)
	unroaded	125	1.90 (0.39)	6.79 (0.93)	2.74 (0.80)	3.35 (0.53)	0.02 (0.02)	0.15 (0.07)	0.02 (0.02)	0.13 (0.05)	0.12 (0.11)	0.01 (0.01)
AA	managed	32	2.22 (0.98)	3.59 (0.92)	0.03 (0.03)	0.42 (0.31)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
	unroaded	48	1.99 (0.93)	4.97 (0.93)	0.23 (0.10)	0.99 (0.36)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)	0.07 (0.03)	0.00 (0.00)	0.00 (0.00)

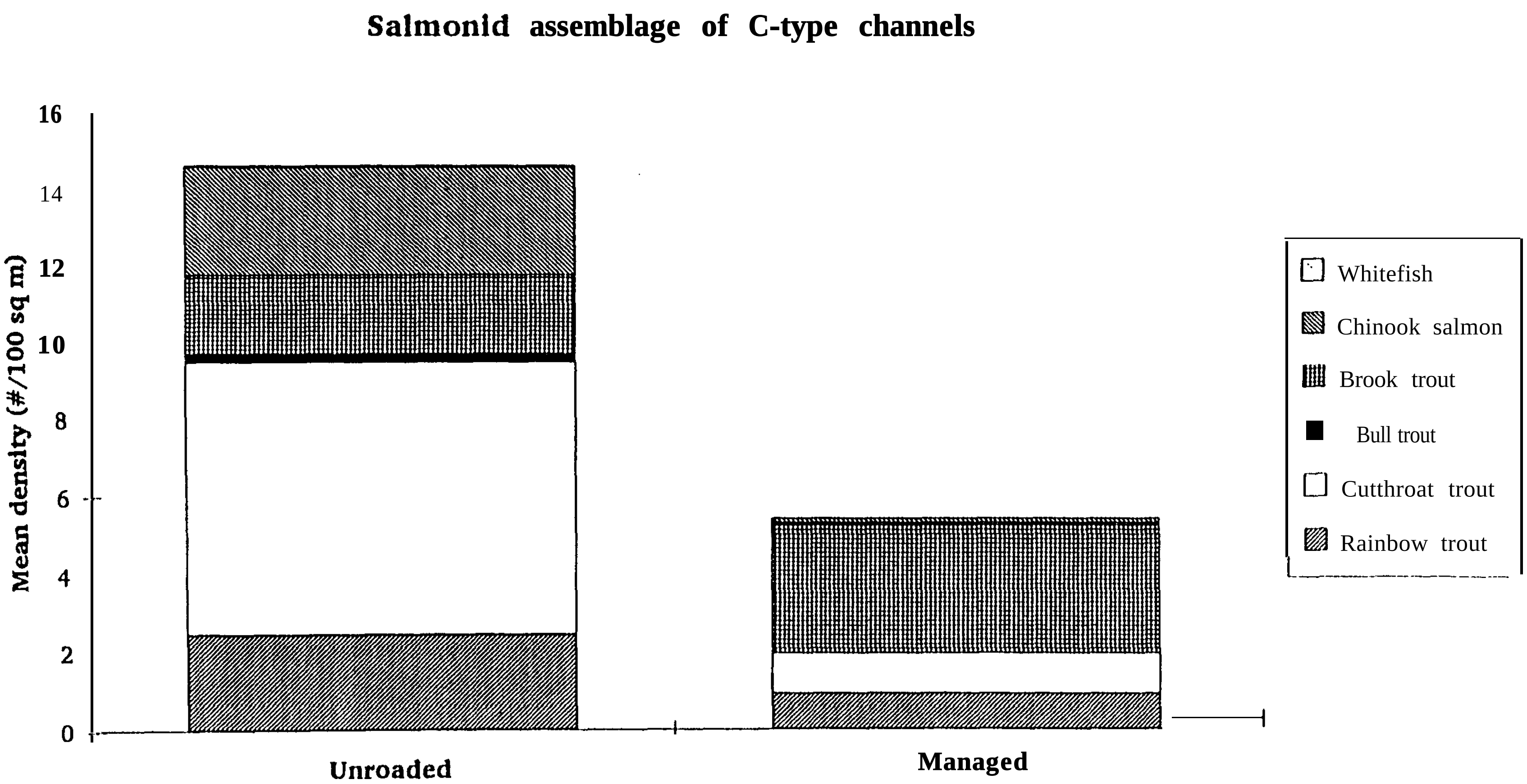

Figure 15. Mean salmonid assemblages found at stations in unroaded (n=11) and managed (n=128) C-type stream channels within the Clearwater National Forest, 1989-1993.

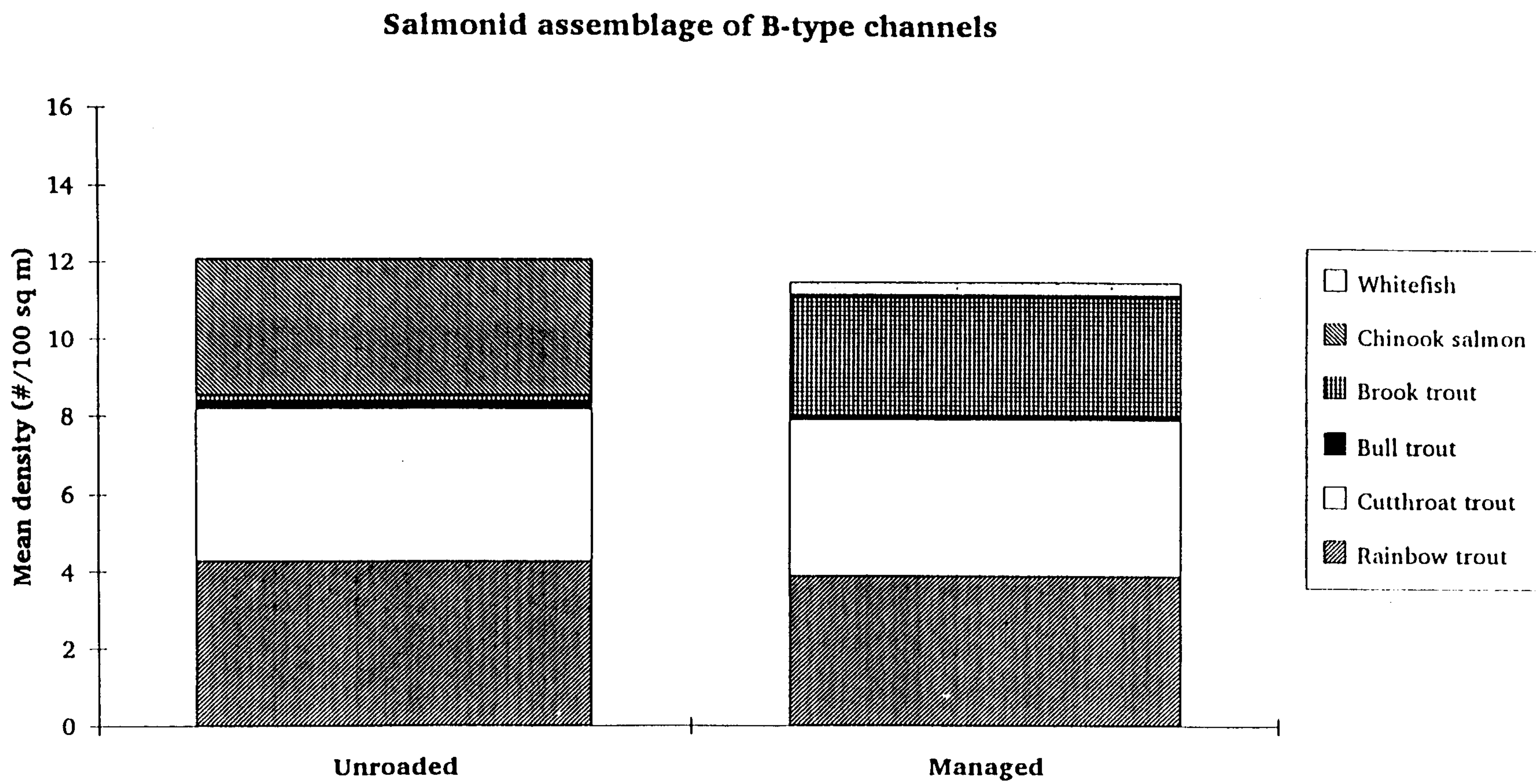

Figure 16. Mean salmonid assemblages found at stations in unroaded (n=72) and managed (n=136) B-type stream channels within the Clearwater National Forest, 1989-1993.

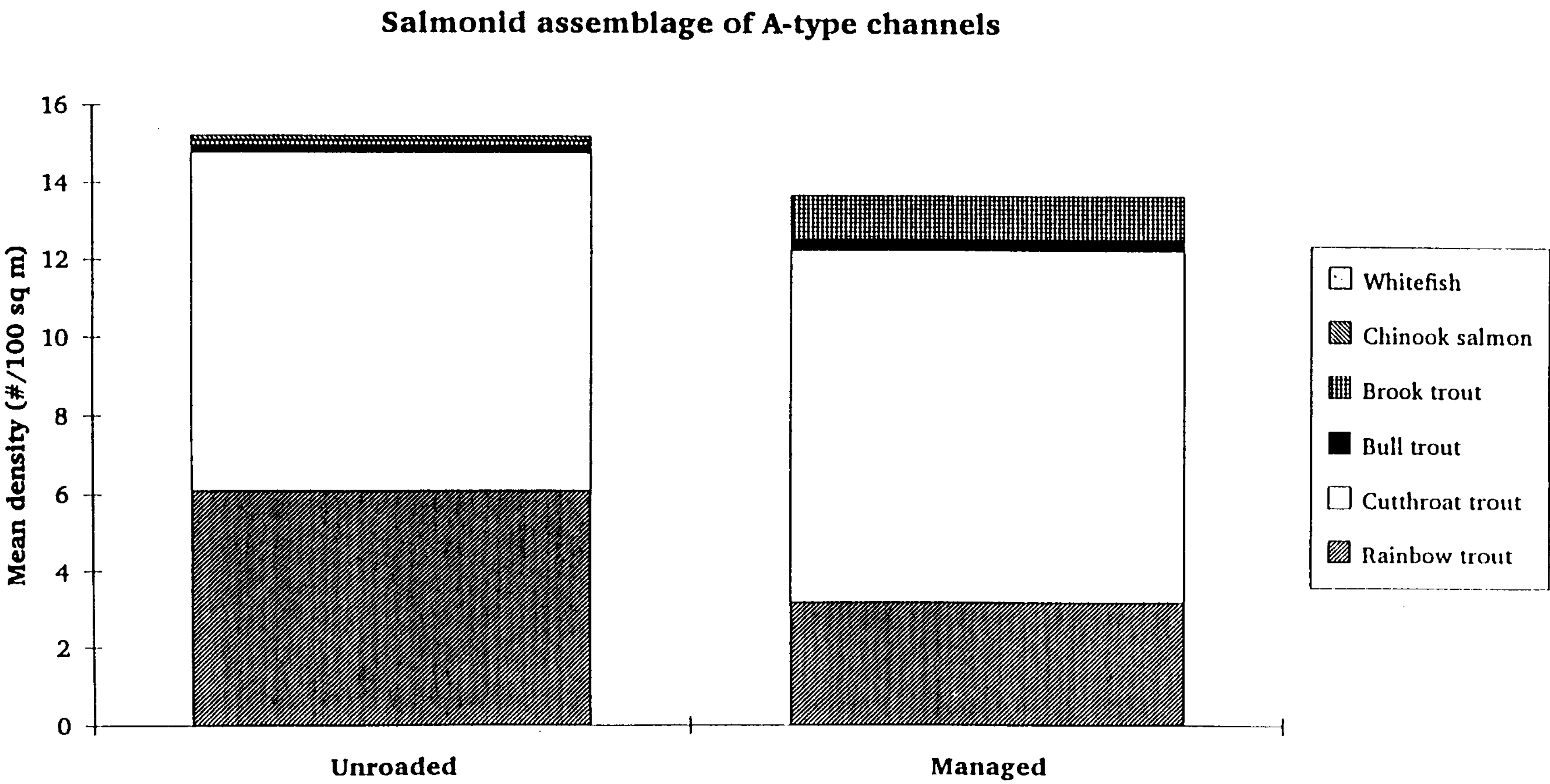

Figure 17. Mean salmonid assemblages found at stations in unroaded (n=125) and managed (n=116) A-type stream channels within the Clearwater National Forest, 1989-1993.

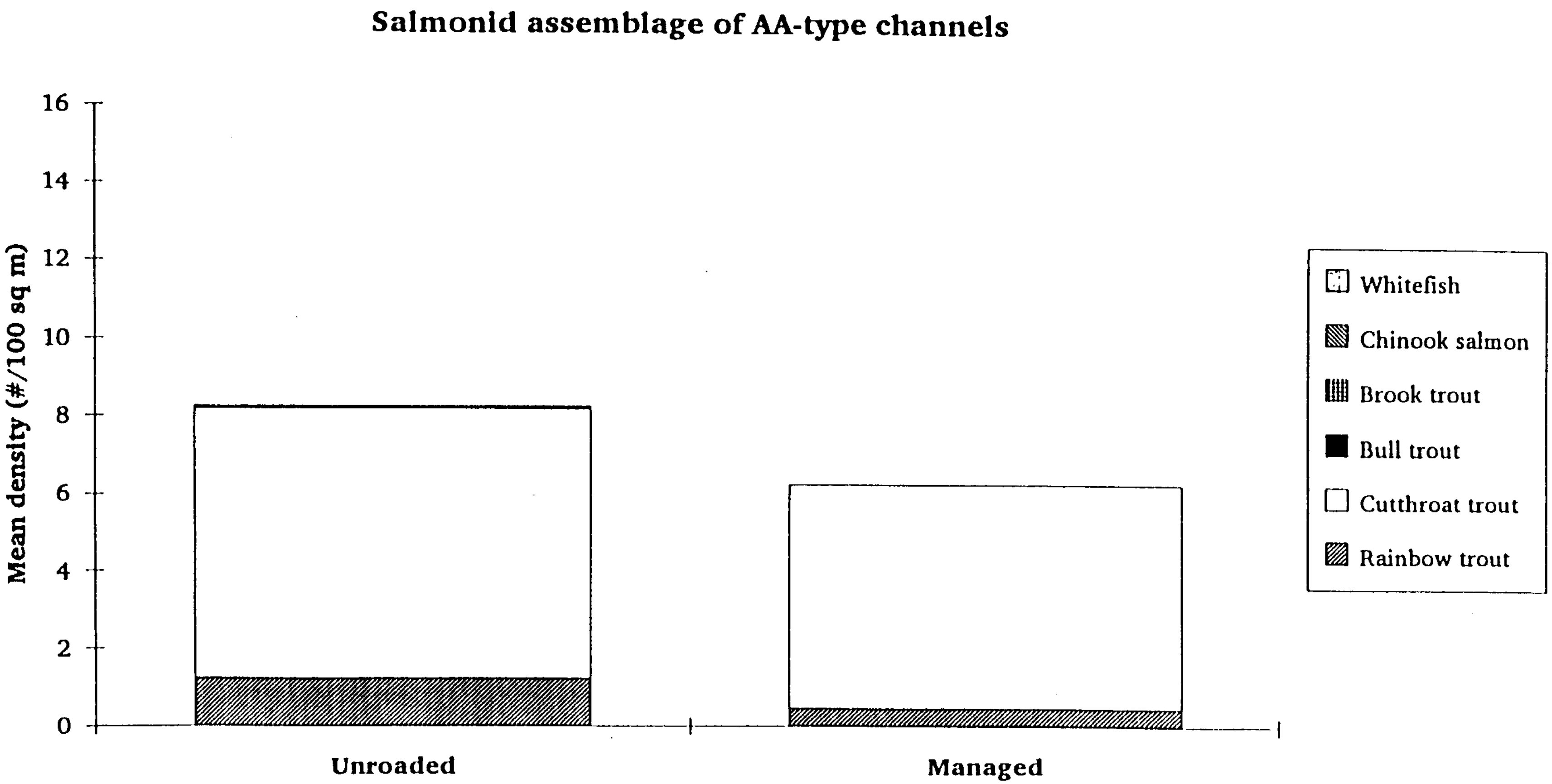

Figure 18. Mean salmonid assemblages found at stations in unroaded (n=48) and managed (n=32) AA-type stream channels within the Clearwater National Forest, 1989-1993.

Introduced brook trout tended to be numerically important members of the salmonid assemblages in managed landscapes on the CNF, particularly in lower gradient B- and C-type stream channels. The species was also a relatively abundant member of the salmonid assemblages of C-type stream channels downstream of certain headwater lakes within unroaded landscapes. Brook trout presence in those channels was a consequence of historic releases of the species into the lakes.

Abundance of Overyearling Trout by Channel Type and Landscape Treatment.

Numerical densities of young-of-year trout are highly variable in streams and can often mask major differences in the abundance of older aged fish. For this reason, the numerical densities of overyearling trout (those at least one year old) in streams should be better indicators of population responses to habitat conditions than are the combined numerical densities of trout of all ages.

Mean densities of overyearling cutthroat, rainbow-steelhead, bull and brook trout at the stations we have sampled on the CNF are stratified by channel type and landscape. treatment in Figures 19-22. Generally, numerical densities of overyearling cutthroat were highest in A-type channels and higher within unroaded areas than in managed landscapes. Differences in cutthroat abundance between landscape treatments were greatest in C-type channels, where average overyearling abundance was over seven times as great in unroaded areas.

Overyearling rainbow-steelhead showed variable differences in abundance between landscape treatments, but like cutthroat were generally more abundant in unroaded C-type channels than in managed ones. Mean abundance of over-yearling rainbow-steelhead was highest in unroaded A-type channels.

Overyearling bull trout tended to be more abundant at stations sampled in unroaded landscapes than at stations in managed areas, while the reverse was true for brook trout. This pattern held for stations on C, B and A-type channels. For bull trout, the pattern may

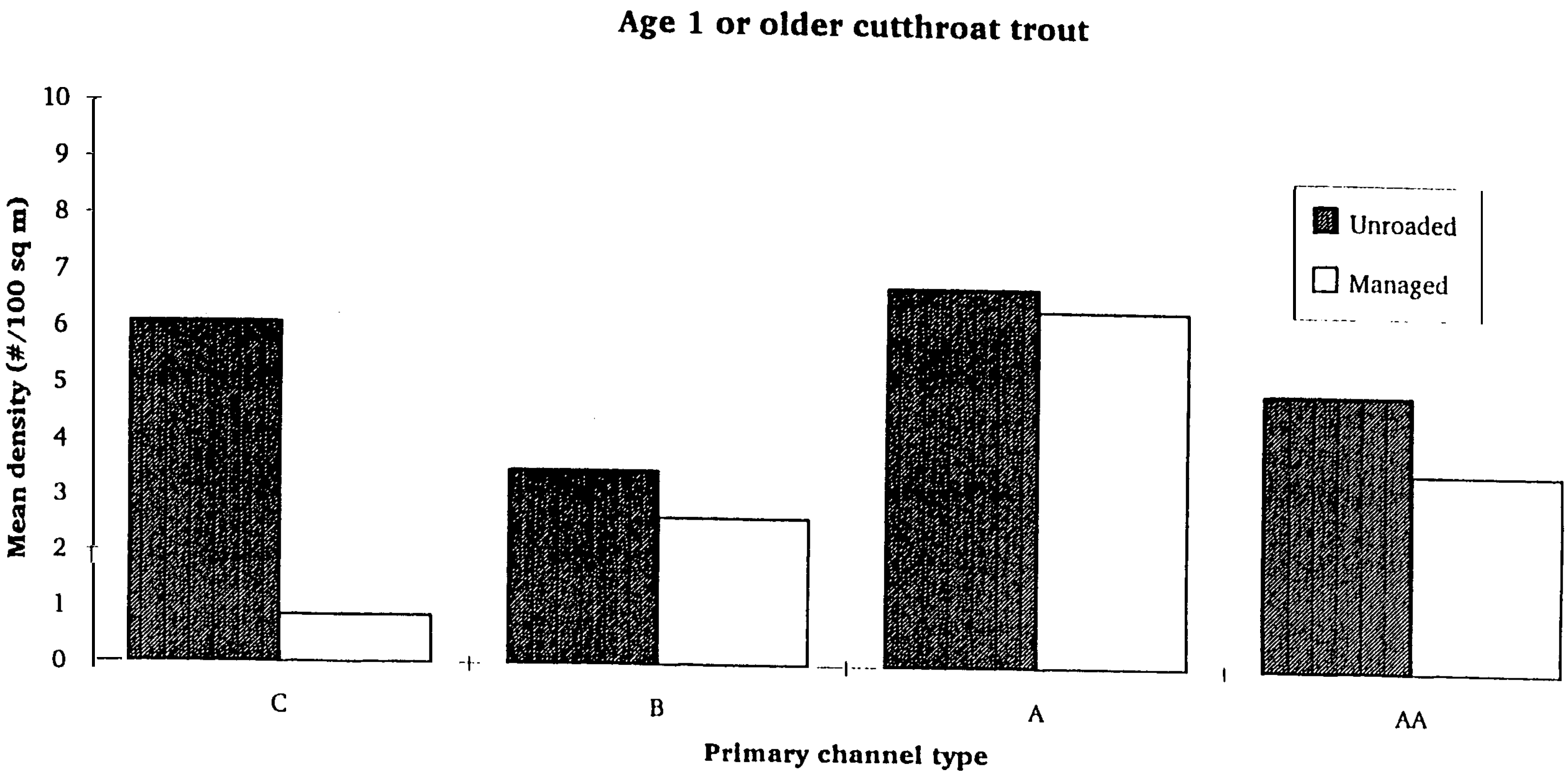

Figure 19. Mean densities of overyearling (age 1 or older) cutthroat trout, by primary channel type and landscape treatment (managed v. unroaded), Clearwater National Forest, 1989-1993.

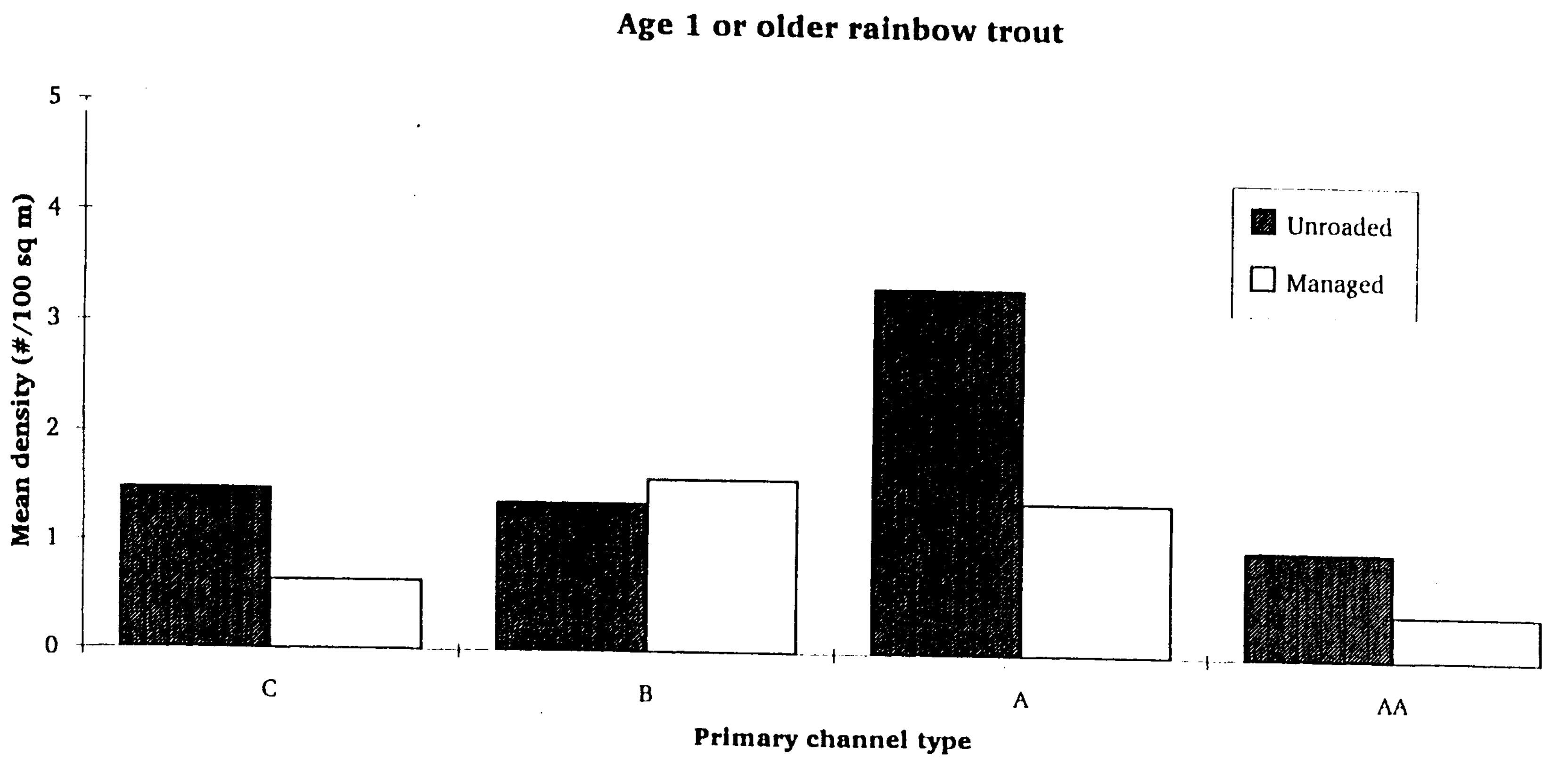

Figure 20. Mean densities of overyearling (age 1 or older) rainbow-steelhead trout, by primary channel type and landscape treatment (managed v. unroaded), Clearwater National Forest, 1989-1993.

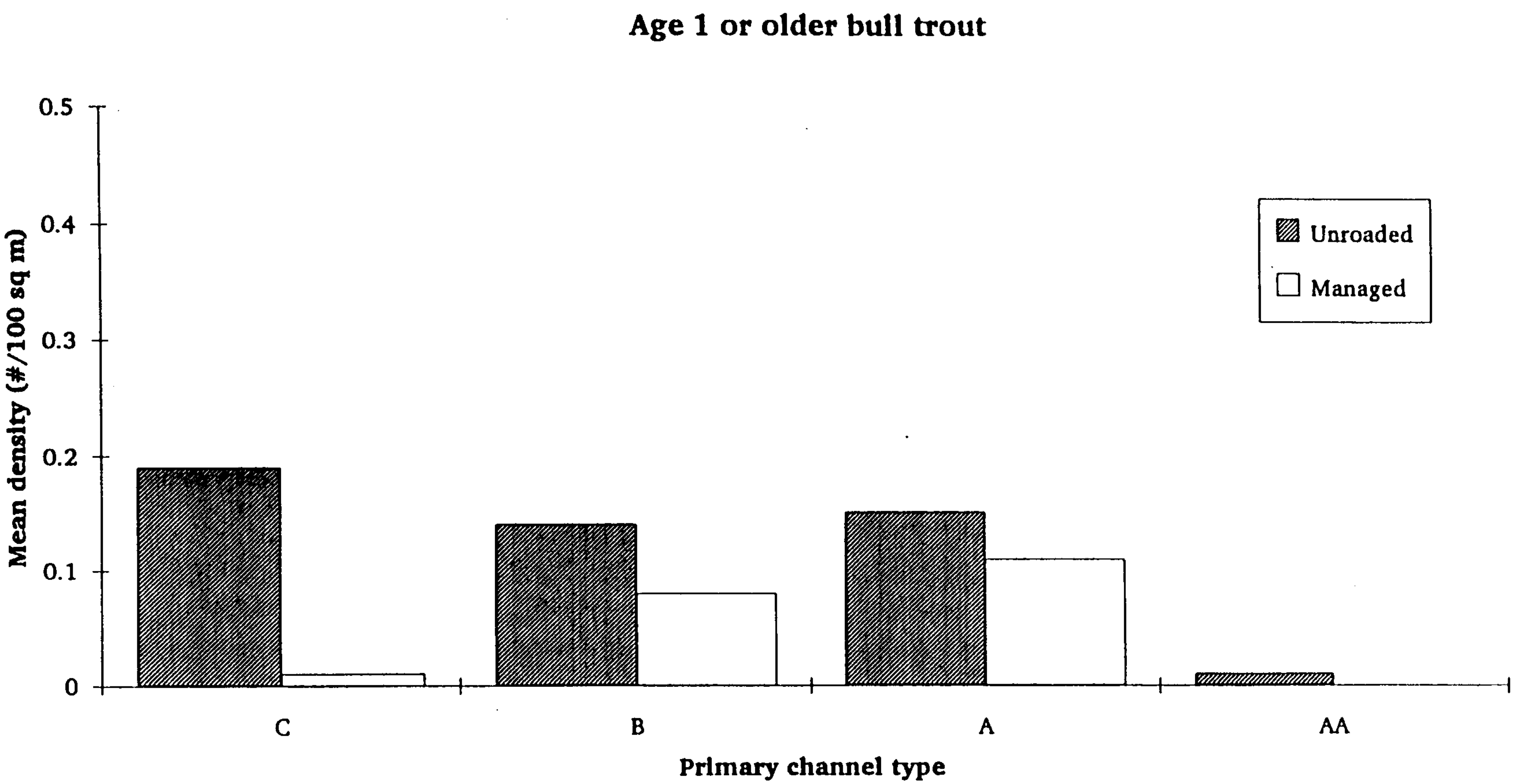

Figure 21. Mean densities of overyearling (age 1 or older) bull trout, by primary channel type and landscape treatment (managed vs. unroaded), Clearwater National Forest, 1989-1993.

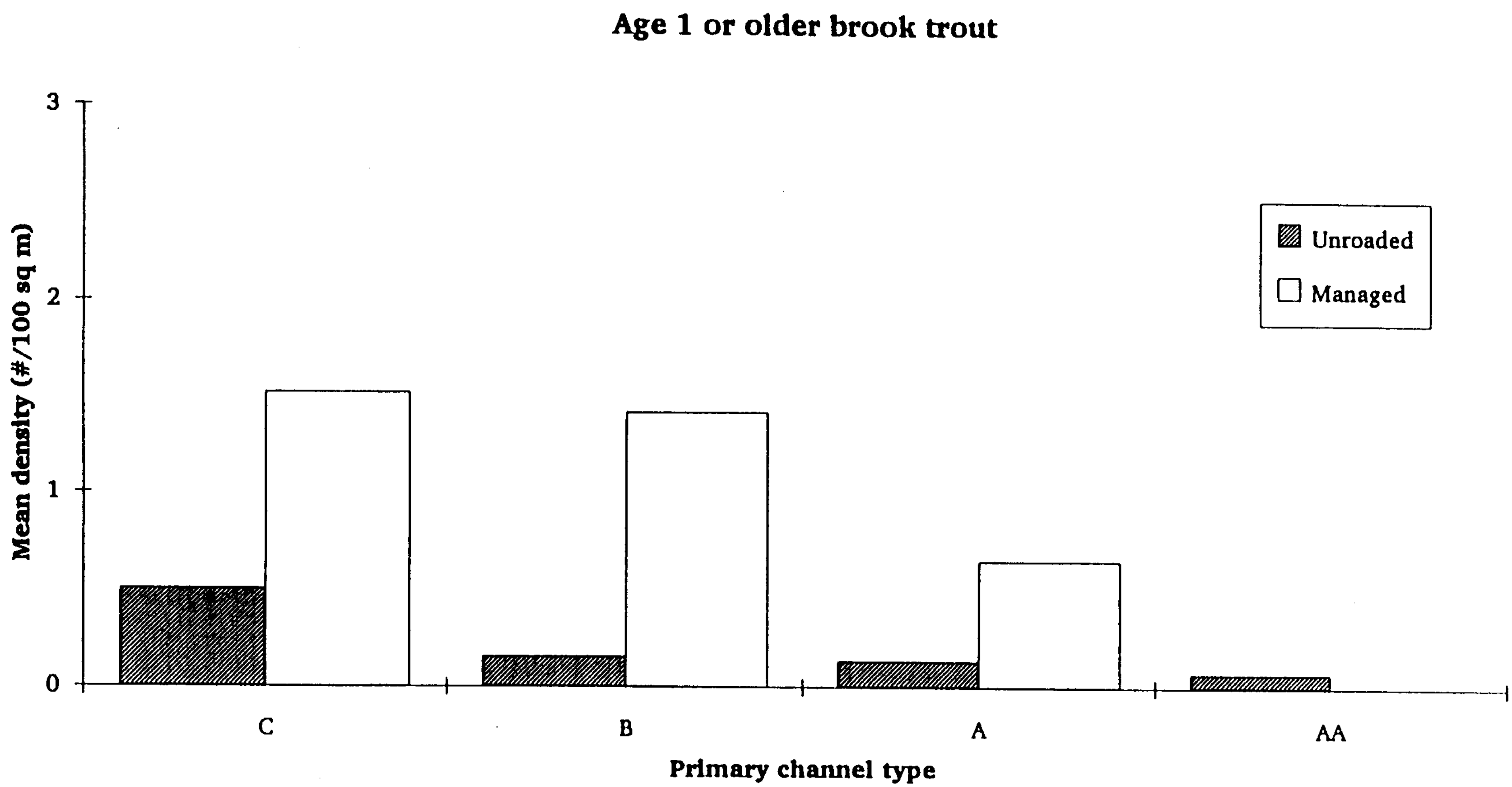

Figure 22. Mean densities of overyearling (age 1 or older) brook trout, by primary channel type and landscape treatment (managed vs. unroaded), Clearwater National Forest, 1989-1993.

reflect better habitat quality or a lower level of angling mortality in unroaded areas. The relatively higher abundance of brook trout within managed streams reflects more frequent introductions of the species into landscapes easily accessible to humans and perhaps a competitive advantage brook trout have over native species in streams with higher levels of sueambed sedimentation.

Cumulative Frequency Distributions for Overyearling Trout Abundance.

Cumulative frequency distributions for the abundance of over-yearling cutthroat, bull and brook trout at the stations we sampled on the CNF are given in Figures 23-34. The figures show differences in both the frequency of occurrence and the abundance of these fish between managed and unroaded landscapes.

Overyearling westslope cutthroat were generally present at a higher percentage of sampled stations, and at higher levels of abundance, in unroaded than in managed C, B, and AA-type channels. However, we found little overall difference in the frequency of occurrence or the abundance of overyearling cutthroat between stations in unroaded and managed A-type channels, where these fish were most abundant. The pattern of cutthroat abundance in A-type channels was unexpected because cutthroat trout are generally thought to have been eliminated from certain managed watersheds through a combination of habitat modification and introductions of non-native species (brook or rainbow trout).

Overyearling bull trout were restricted to a relatively small percentage of the stations we sampled within the CNF's C, B and A-type channels, and were virtually absent from stations in AA-type channels. At stations within each of the three major channel types that did infrequently contain bull trout, both the frequency of occurrence and the abundance of over-yearling fish was higher in unroaded than in managed landscapes.

In contrast to cutthroat and bull trout, over-yearling brook trout generally occurred at higher percentages of stations, and at higher levels of abundance, in managed than in unroaded areas. The difference between landscape treatments was most pronounced in

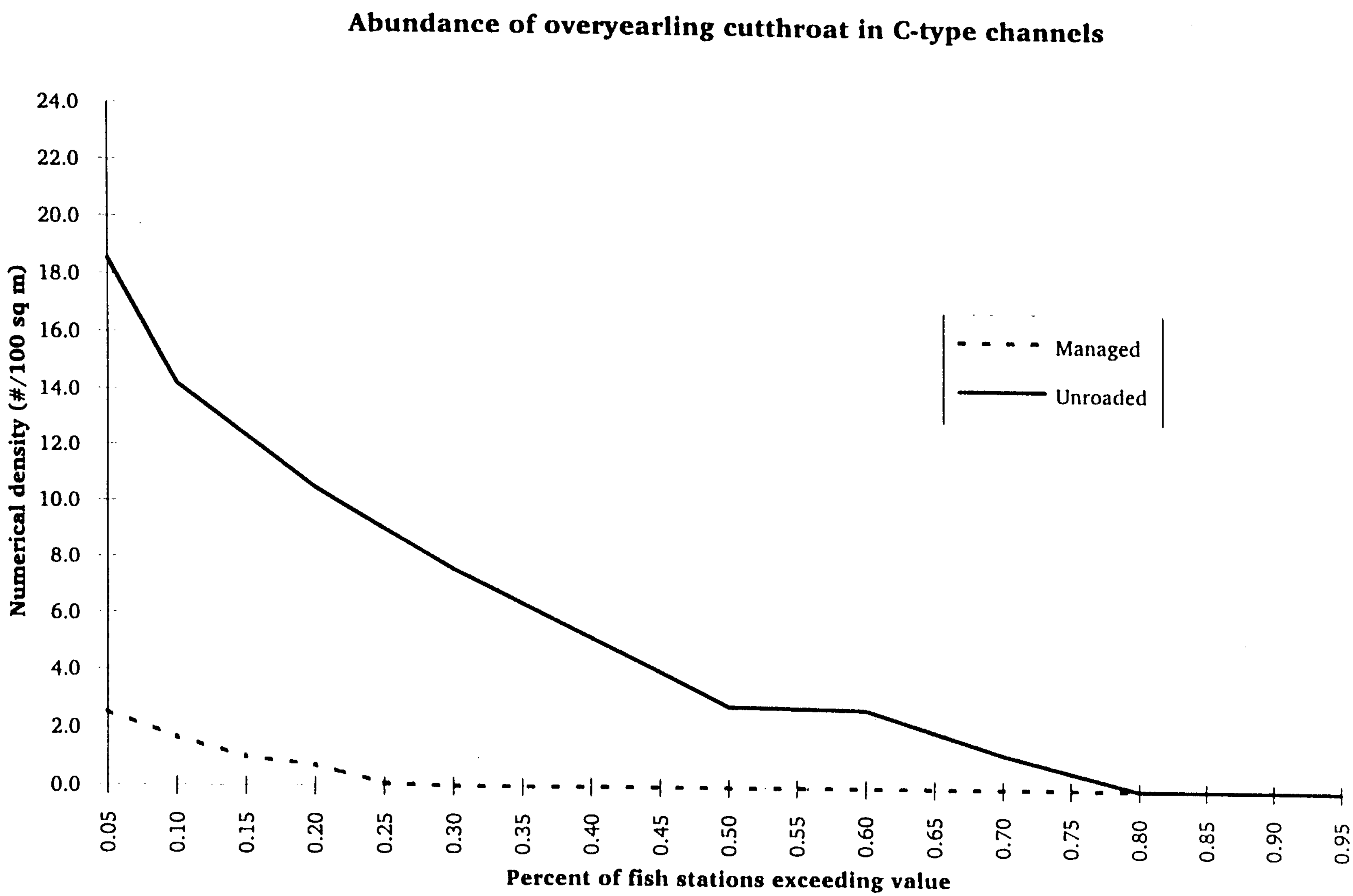

Figure 23. Cumulative frequency distributions for the abundance of overyearling cutthroat trout (#/100 m^2) at fish stations in managed (n=128) versus unroaded (n=11) C-type stream channels, Clearwater National Forest, 1989-1993.

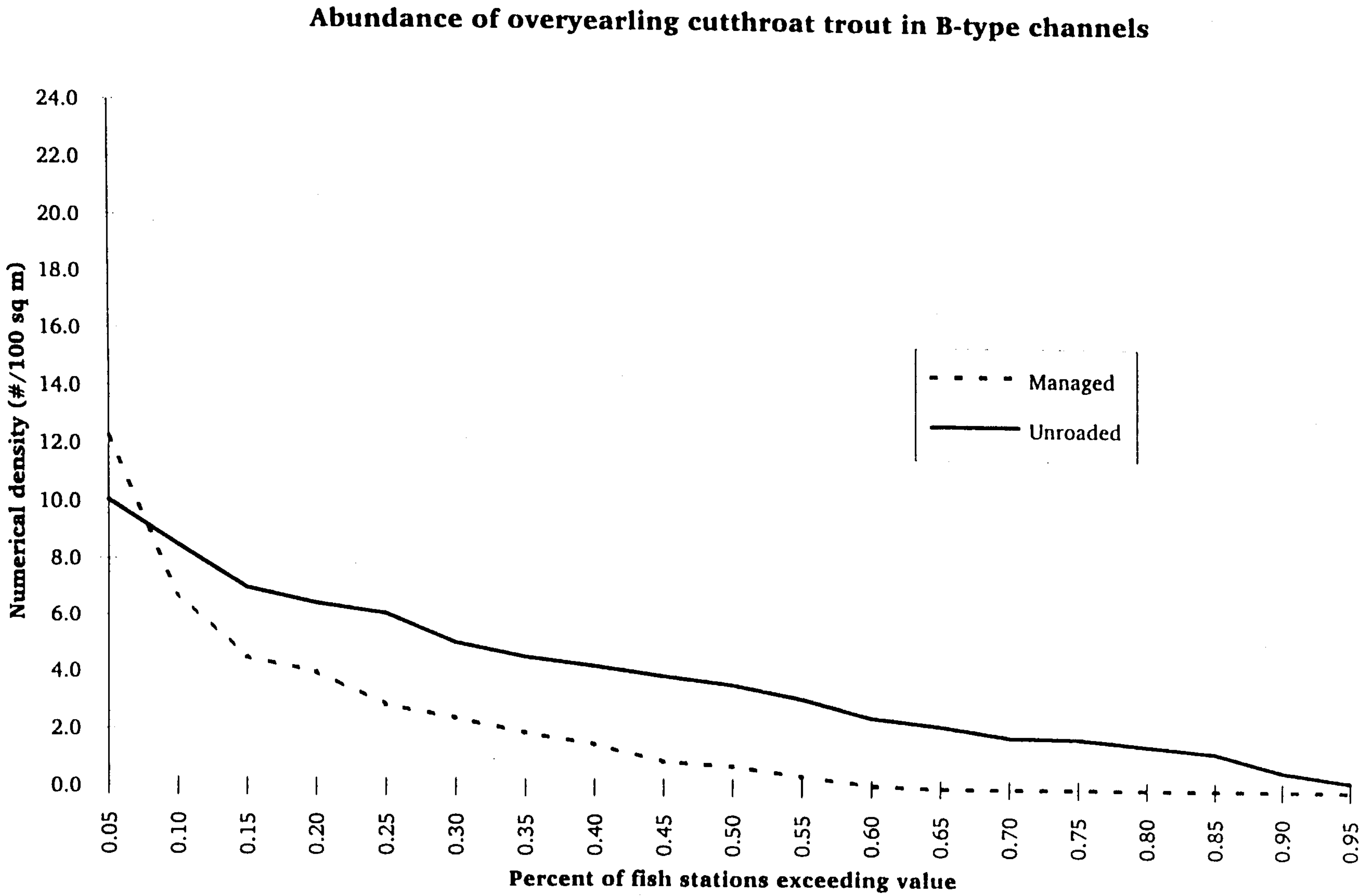

Figure 24. Cumulative frequency distributions for the abundance of overyearling cutthroat trout ($\#/100\ m^2$) at fish stations in managed (n=136) versus unroaded (n=72) B-type stream channels, Clearwater National Forest, 1989-1993.

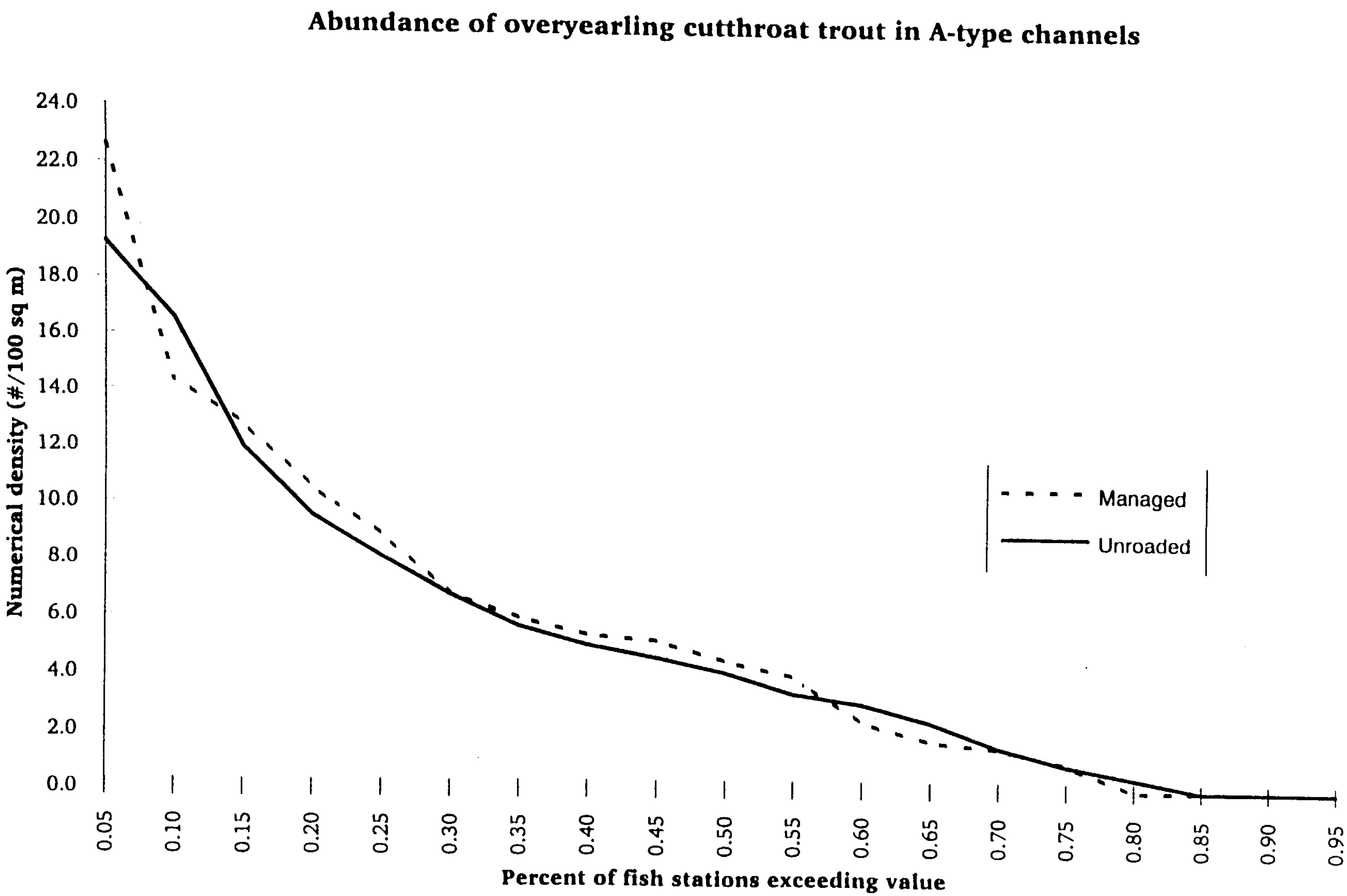

Figure 25. Cumulative frequency distributions for the abundance of overyearling cutthroat trout ($\#/100\ m^2$) at fish stations in managed (n=116) versus unroaded (n=125) A-type stream channels, Clearwater National Forest, 1989-1993.

Abundance of overyearling cutthroat trout in AA-type channels

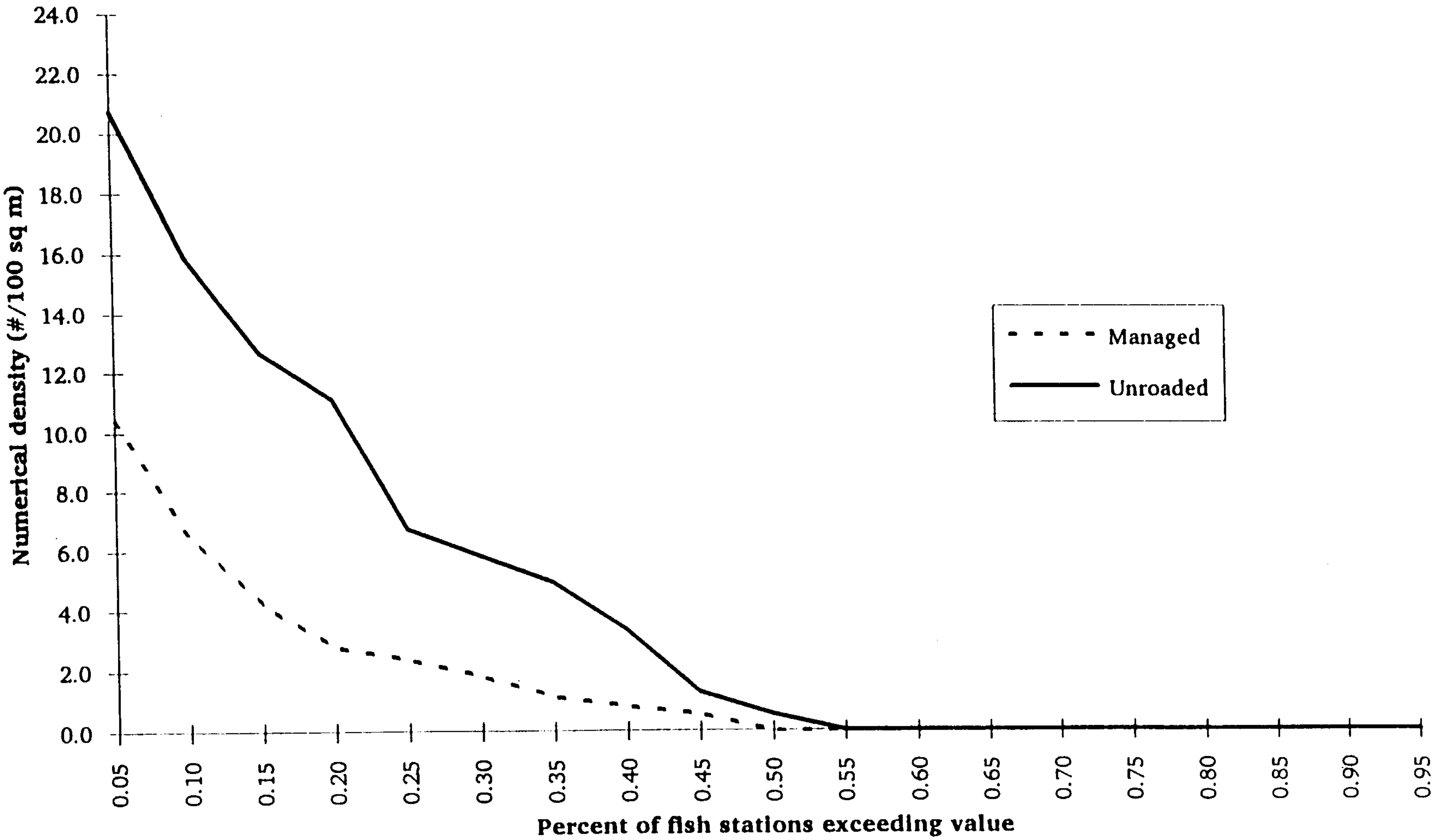

Figure 26. Cumulative frequency distributions for the abundance of overyearling cutthroat trout (#/100 m^2) at fish stations in managed (n=32) versus unroaded (n=48) AA-type stream channels, Clearwater National Forest, 1989-1993.

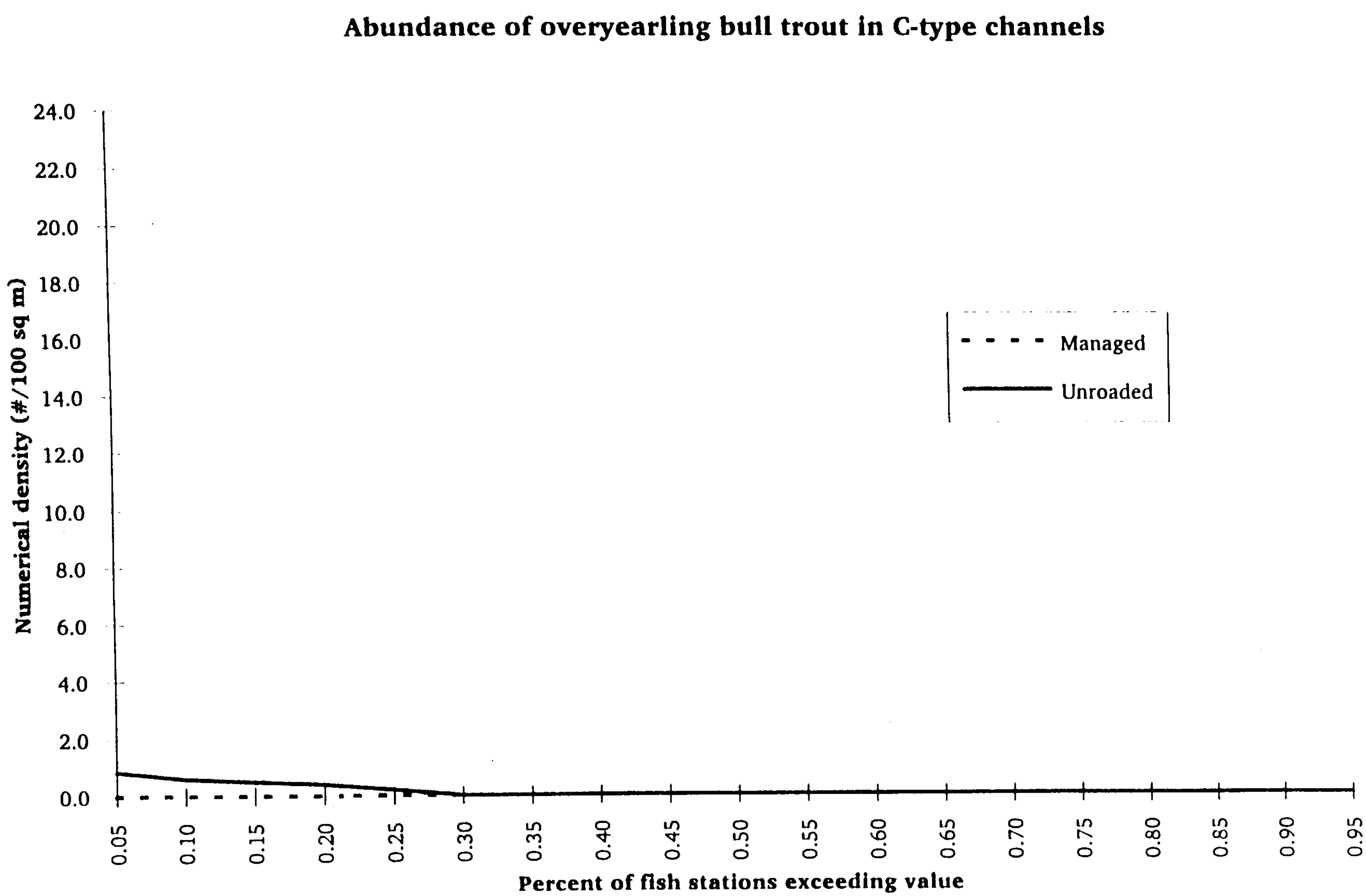

Figure 27. Cumulative frequency distributions for the abundance of overyearling bull trout (#/100 m^2) at fish stations in managed (n=128) versus unroaded (n=11) C-type stream channels, Clearwater National Forest, 1989-1993.

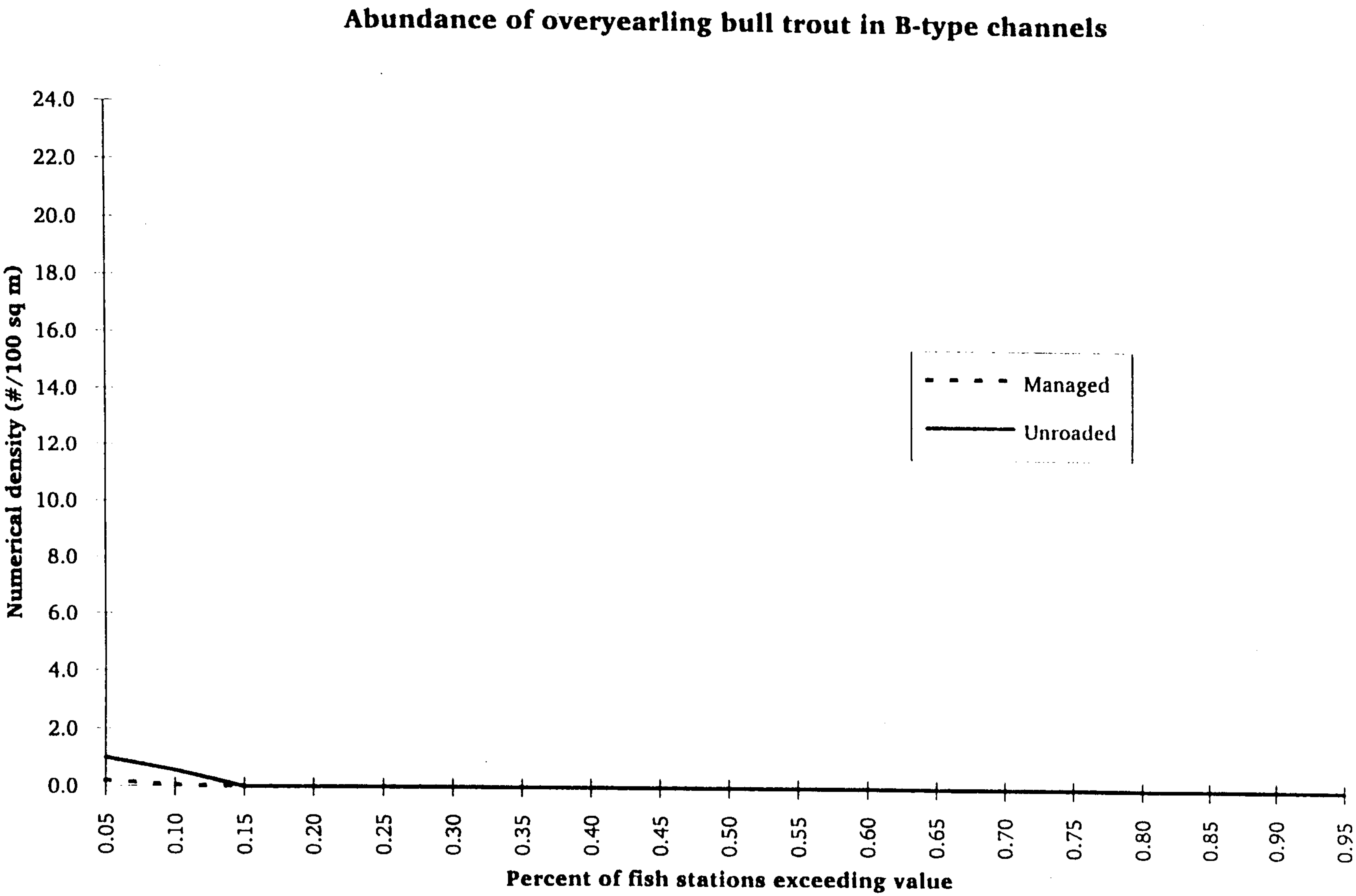

Figure 28. Cumulative frequency distributions for the abundance of overyearling bull trout (#/100 m^2) at fish stations in managed (n=136) versus unroaded (n=72) B-type stream channels, Clearwater National Forest, 1989-1993.

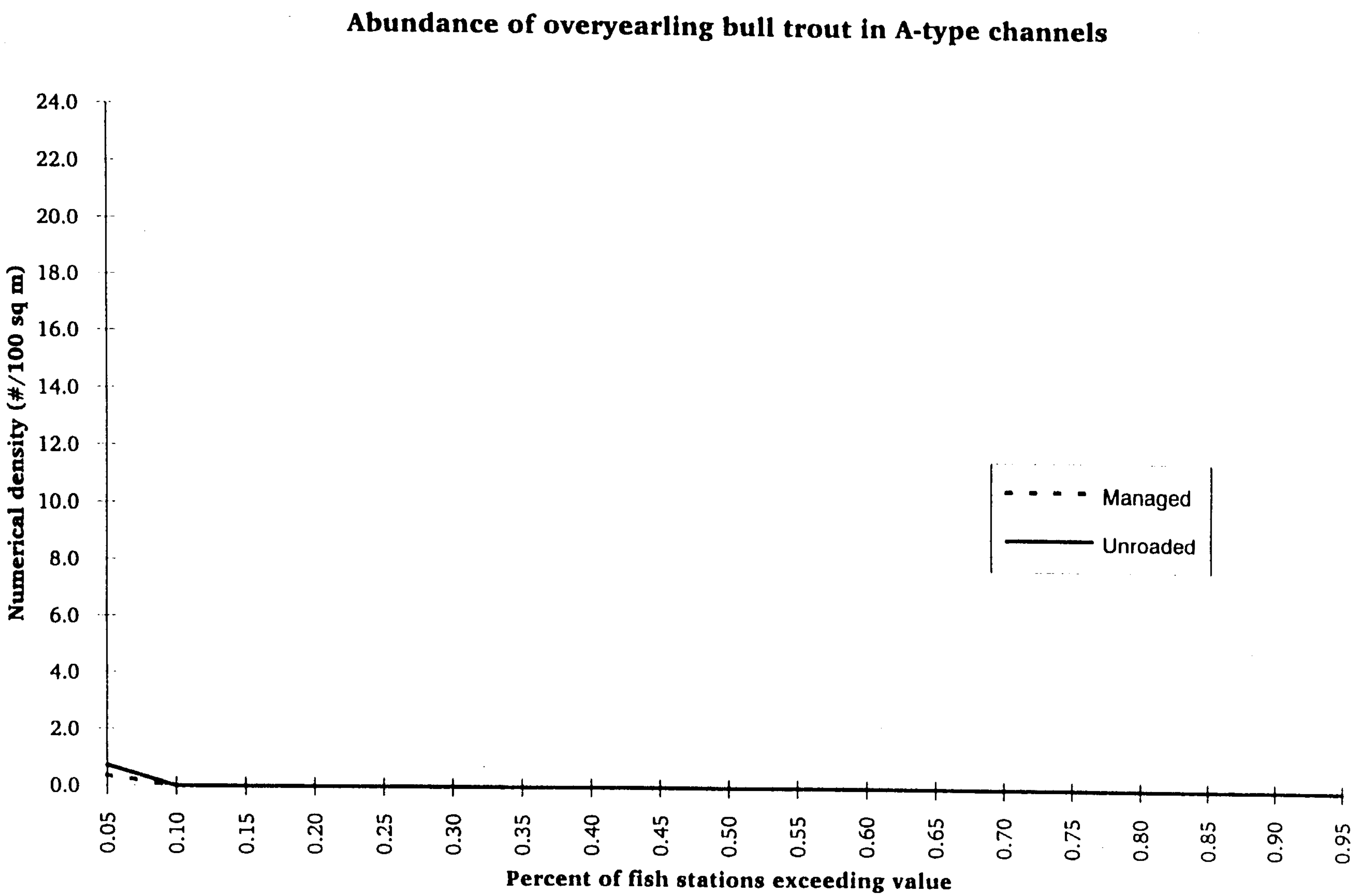

Figure 29. Cumulative frequency distributions for the abundance of overyearling bull trout (#/100 m^2) at fish stations in managed (n=116) versus unroaded (n=125) A-type stream channels, Clearwater National Forest, 1989-1993.

Abundance of overyearling bull trout in AA-type channels

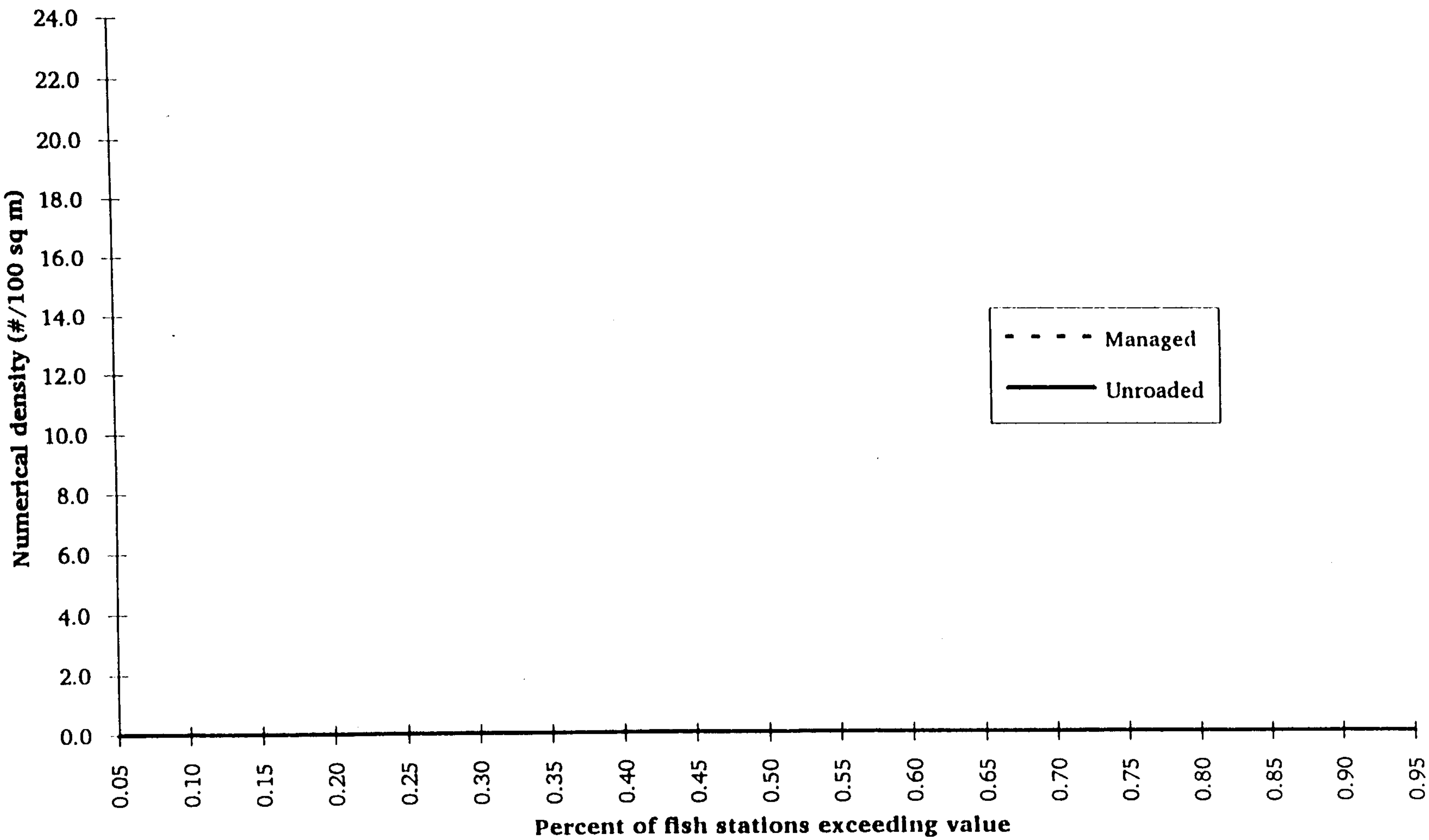

Figure 30. Cumulative frequency distributions for the abundance of overyearling bull trout (#/100 m^2) at fish stations in managed (n=32) versus unroaded (n=48) AA-type stream channels, Clearwater National Forest, 1989-1993.

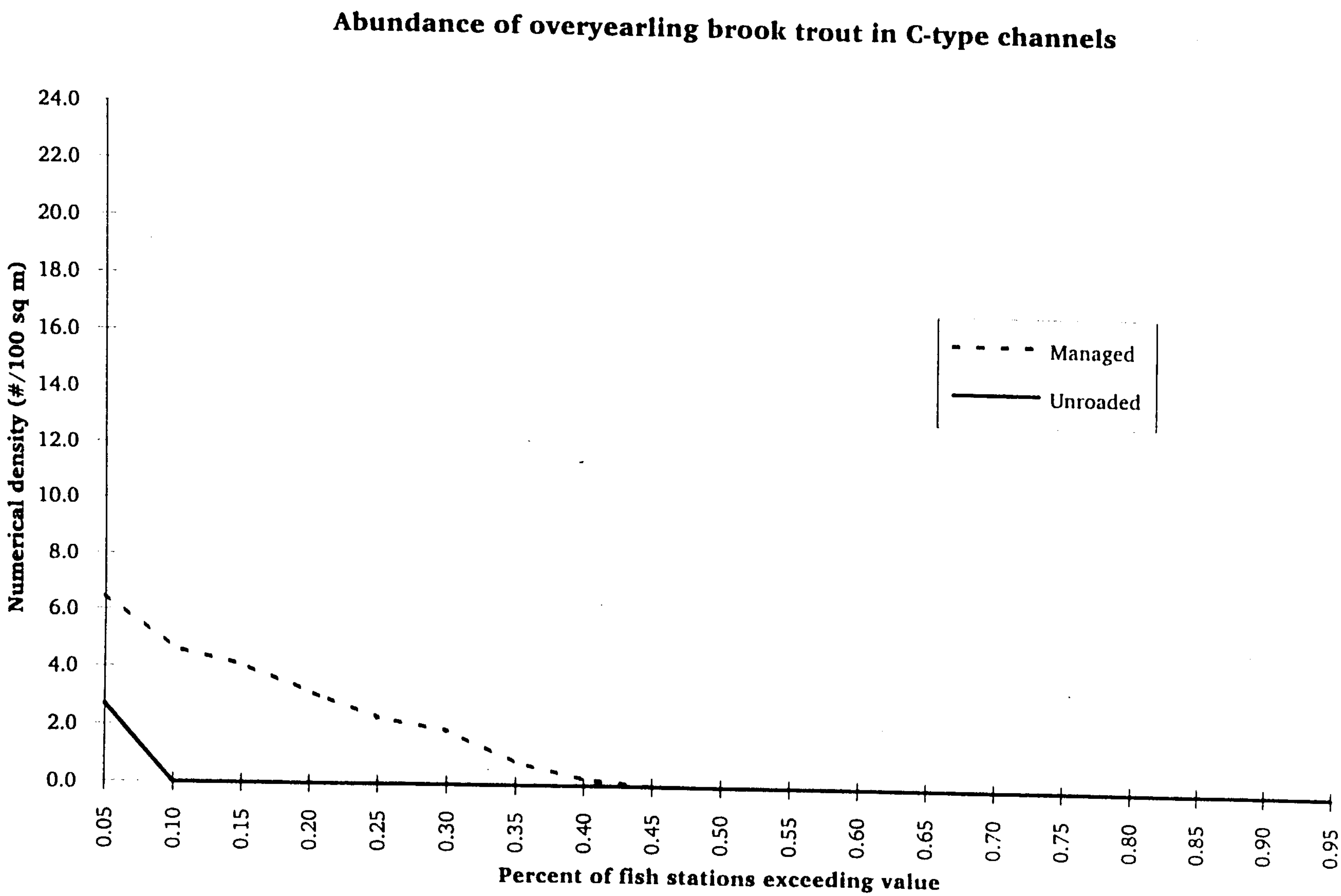

Figure 31. Cumulative frequency distributions for the abundance of overyearling brook trout (#/100 m^2) at fish stations in managed (n=128) versus unroaded (n=11) C-type stream channels, Clearwater National Forest, 1989-1993.

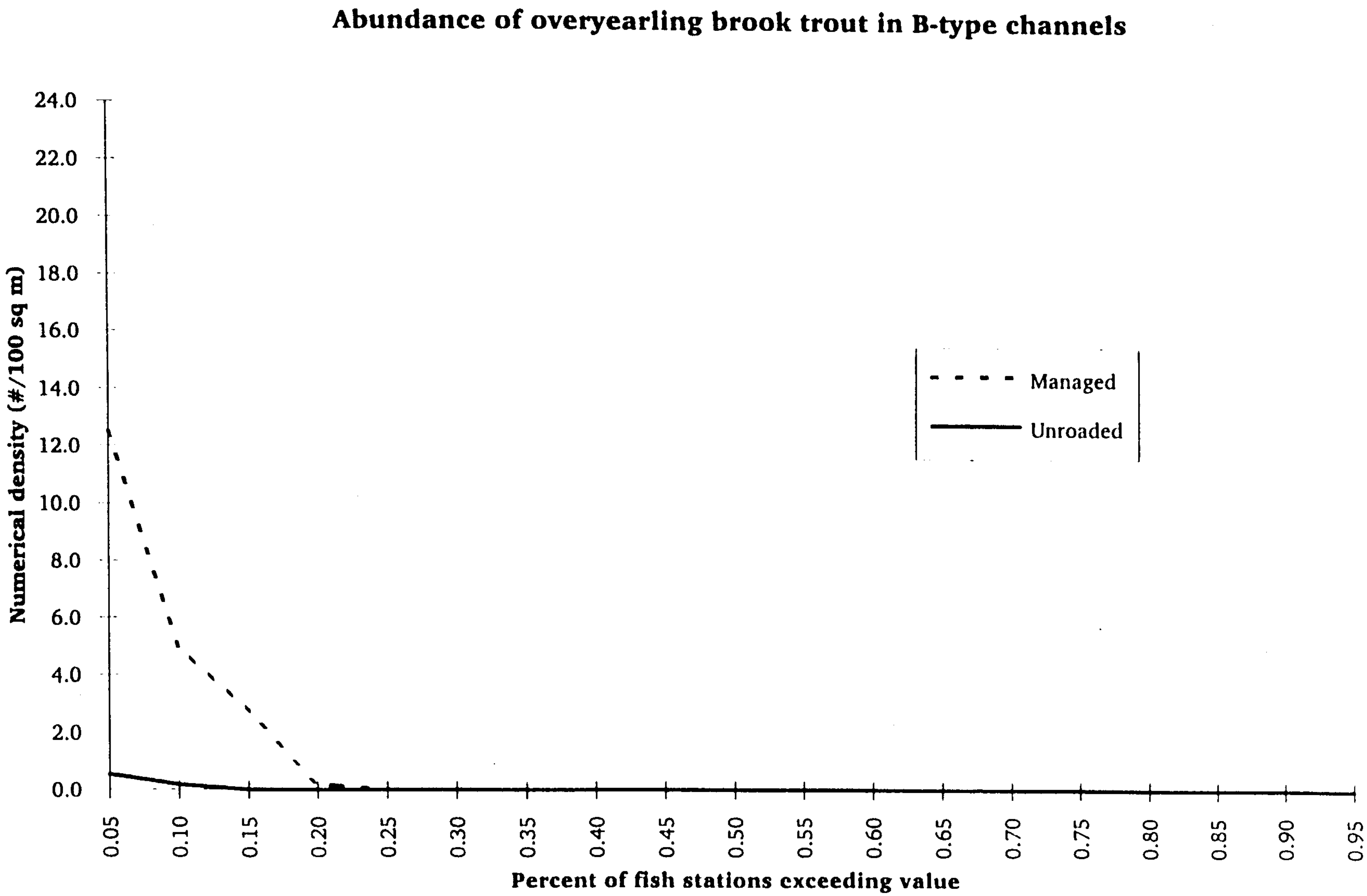

Figure 32. Cumulative frequency distributions for the abundance of overyearling brook trout (#/100 m^2) at fish stations in managed (n=136) versus unroaded (n=72) B-type stream channels, Clearwater National Forest, 1989-1993.

Abundance of overyearling brook trout in A-type channels

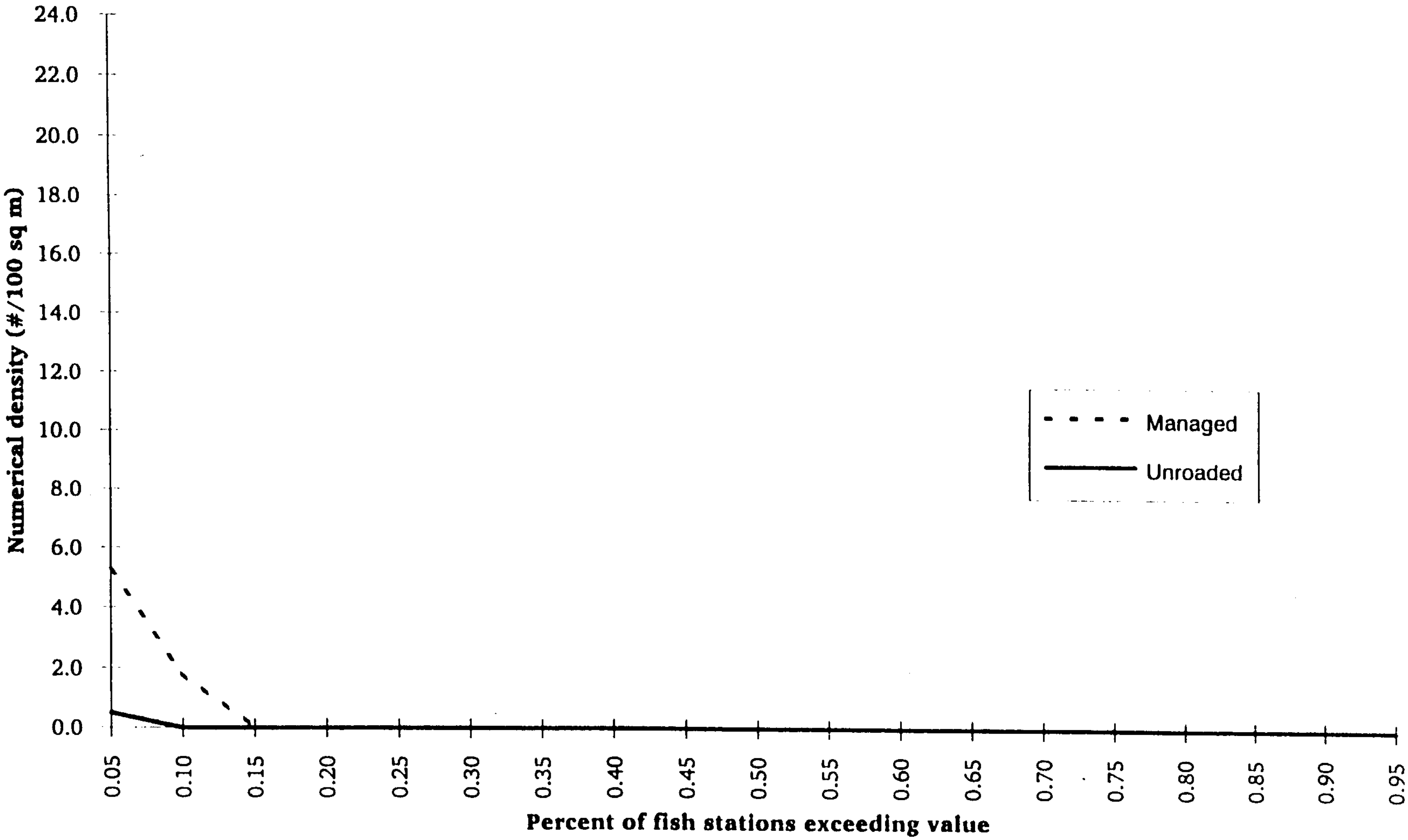

Figure 33. Cumulative frequency distributions for the abundance of overyearling brook trout (#/100 m^2) at fish stations in managed (n=116) versus unroaded (n=125) A-type stream channels, Clearwater National Forest, 1989-1993.

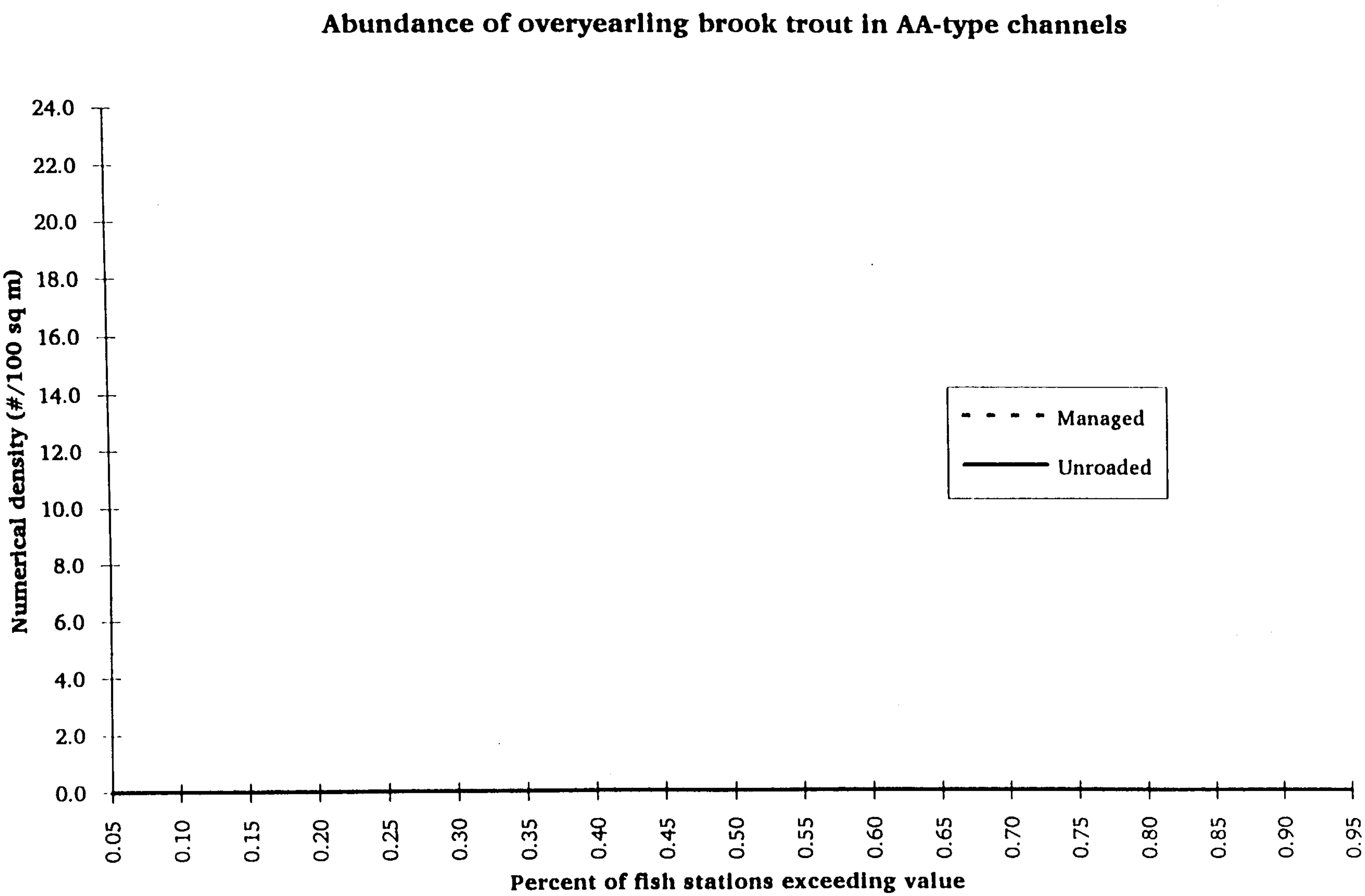

Figure 34. Cumulative frequency distributions for the abundance of overyearling brook trout (#/100 m^2) at fish stations in managed (n=32) versus unroaded (n=48) AA-type stream channels, Clearwater National Forest, 1989-1993.

B and A-type channels. However, in spite of their relative abundance within managed landscapes, brook trout were still present at a smaller percentage of the stations sampled within those landscapes than were native cutthroat trout.

SUMMARY

Overall, substantial differences exist between streams in managed and unroaded areas of the CNF. The differences reflect the interaction of anthropogenic disturbances and natural variation across the landscape (including variable influences of historic forest fires). Data we have collected and direct personal observations suggest that much of the best fish habitat on the CNF is in unroaded areas, where levels of fine streambed sediment are generally lower than in managed landscapes. However, stream conditions within the CNF's unroaded areas should not be looked upon as ideal because aquatic and riparian resources within a high. proportion of the Forest’s roadless landscapes are still recovering from catastrophic fires that occurred within the last 50-150 years.

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APPENDIX A -- FISH HABITAT DATABASE

The following parameters are contained within HABITAT.XLS, our database on fish habitat conditions along 1320 reaches of stream within the Clearwater National Forest:

Dist - Ranger District (PW=Powell, LO=Lochsa, PC=Pierce, NF=North Fork PL=Palouse)

Year - year reach was surveyed

Stream - stream code

Reach - reach number

Mgmt - management regime (MG=managed; UN=unroaded; WI=wilderness)

Elev - midpoint elevation of reach, assigned to one of 13 classes and expressed as the lower bound of the elevation class (300-449m, 450-599m, 600-749m, 750-899m, 900-1049m, 1050-1199m, 1200-1349m, 1350-1499m, 1500-1649m, 1650-1799m, 1800-1949m, 1950-2099m, >2100m)

Chan - primary Rosgen channel type of reach

Length - reach length in meters

Trans - number of transects measured in reach

Grad - mean gradient of stream reach

Width - mean stream width in meters

Depth - mean stream depth in centimeters

Pool - percent of stream surface in pool habitat

Riffle - percent of stream surface in riffle habitat

Run-p - percent of stream surface in pool-like run habitat

Run-r - percent of stream surface in riffle-like run habitat

Pocket - percent of stream surface in pocketwater

Alcove - percent of stream surface in alcove

%pool - percent of stream surface in pool, pocketwater and alcove

Pool-q - mean pool quality rating (1 =poor to 5 =excellent)

I-cover - mean instream cover rating (1 = poor to 5 =excellent)

B-cover - mean bank cover rating (1 =poor to 5=excellent)

B-stab - mean bank stability rating (1 = poor to 5 =excellent)

Embed - mean percent cobble embeddedness

Act-deb - mean quantity of acting debris (#/100m)

Pot-deb - mean quantity of potential debris (#/100m)

Bdrk - percent of streambed dominated by bedrock

Boldr - percent of streambed dominated by boulders (>305mm)

Rubble - percent of streambed dominated by rubble (153-305mm)

Cobble - percent of streambed dominated by cobble (76-152mm)

C-grav - percent of streambed dominated by coarse gravel (26-75mm)

F-grav - percent of streambed dominated by fine gravel (6-25mm)

Fines - percent of streambed dominated by fine sediments (<6mm)

APPENDIX B -- SALMONID ABUNDANCE DATABASE

The following parameters are contained within FISH.XLS, our database on salmonid abundance at 668 fish stations sampled within the Clearwater National Forest.

Station - station code

Dist - Ranger District

Year - year station was sampled

Stream - stream code

Reach - number of reach containing fish station

Chan - primary Rosgen channel type for reach containing fish station

Mgmt - management regime

Elev-m - midpoint elevation of reach containing station, assigned to one of 13 classes and expressed as the lower bound of the elevation class

Width - mean stream width of reach containing fish station

Embed- mean percent cobble embeddedness of reach containing fish station

Area - surface area of station, expressed in square meters

Rbt0 - numerical density (#/100 sq m) of age 0 rainbow-steelhead

Rbtl - numerical density of age 1 rainbow-steelhead

Rbt2+ - numerical density of age 2 or older rainbow-steelhead

Cutt0 - numerical density of age 0 cutthroat trout

Cutt1 - numerical density of age 1 cutthroat trout

Cutt2+ - numerical density of age 2 or older cutthroat trout

Bull0 - numerical density of age 0 bull trout

Bull 1 - numerical density of age 1 bull trout

Bull2+ - numerical density of age 2 or older bull trout

Bkt0 - numerical density of age 0 brook trout

Bktl - numerical density of age 1 brook trout

Bkt2+ - numerical density of age 2 or older brook trout

Wfish - numerical density of mountain whitefish (all ages)

Chin0 - numerical density of age 0 chinook salmon

Chin1+ - numerical density of age 1 or older chinook salmon

APPENDIX C -- STREAM REACH AND FISH STATION MAPS

Specific locations of the stream reaches and fish stations included in our Clearwater databases are delineated on 1:100,000 scale USGS topographic maps on file with the Eastside Ecosystem Management Project offices in Walla Walla, Washington.